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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 5 NO. 58 OCTOBER 1959

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VOLUME 5 NUMBER FIFTY-EIGHT OCTOBER 1959

JOURNAL OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 *Telephone* COVENT GARDEN 1871 *Telegrams* VOLTAMPERE PHONE LONDON

PUBLISHED MONTHLY PRICE SEVEN SHILLINGS ANNUAL SUBSCRIPTION TWO POUNDS

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The heart of the matter

NOT a view of limpets on a rock nor of the Sea of Serenity on the moon but of the material without which the convention on transistors reported on p. 586 would have been impossible is given in this month's cover picture.

It is a Post Office interferogram showing etch pits on a germanium surface. Each fringe separation corresponds to a change in height of $0{\cdot}27\,\mu$. The photograph is reproduced by courtesy of H.M. Postmaster General

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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JOURNAL

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RURAL ELECTRIFICATION

THE Economic Commission for Europe is one of the many supranational bodies set up since the Second World War with the admirable object of drawing together the proud and wounded members of that fissile continent. The commission has a committee on electric power which at its 8th session decided to make a study of rural electrification problems and at its 10th session set up a working party for the task. Last month 21 members of the working party representing 14 nations spent three weeks in the United Kingdom studying rural electrification practice and developments.

The purpose of the working party is to examine some questions in greater detail and give governments an opportunity for a periodic exchange of views. The results of this work are contained in papers on specific subjects prepared by rapporteurs, and so far 24 such reports have been published. In addition the secretariat of the commission were instructed to prepare each year a report on the state of rural electrification in Europe, and the report for 1957 has recently been issued. All European countries except Albania, Belgium, Czechoslovakia, Liechtenstein, Norway, Portugal and Spain took part in the latter inquiry as well as Turkey, the Soviet Union and the United States.

A leading British politician recently referred to the emergence of a new type of citizen—the European. The evidence of the post-war years and of the successful struggles of the European organizations is that there is a powerful current of feeling and opinion, which even laps the shores of this island, striving to regain for Europe its continental unity in a world of continental economics and continental power.

Many people will welcome this trend and applaud the work of such bodies as the Economic Commission for Europe, including these valuable investigations in the field of rural electrification. Even such an apparently simple exercise as the international exchange of technical information has the effect of stimulating progress and encouraging emulation. But apart from this the topic is of vital interest for industrial Europe because it is an essential part of the efforts being made by governments to improve the living standards of rural populations so as to encourage them to stay on the land.

Rural electricity consumption is growing faster than total electric power consumption. For example in 1957 the total consumption in the United Kingdom and Switzerland increased by 4·9 and 5·7% over 1956 while rural consumption grew by 16·8 and 9·8% respectively. The rural inhabitant's consumption was greatest in Sweden, Switzerland, the United Kingdom and the United States, but it is a sign of the times that in the U.S.A. 80% of the rural power sold in 1956 was used in the household and only 20% for farm production. Another notable statistic is that the United States and the United Kingdom are regarded as large-farm countries, the average area of arable land per farm being in the proportions of 40 for the U.S.A., 20 for the United Kingdom, and for Switzerland only 2.

From a general comparison it would seem that rural electrification has progressed further in Germany, the United States, the Netherlands and Switzerland than in some other countries. In Luxembourg the total cost of supply connection to farms is borne jointly by the distributors and the government, the farmers merely being required to undertake to consume a certain annual amount at normal rates. The average cost of connecting a farm was least in Ireland and greatest in Hungary followed by Italy, the United States and the United Kingdom.

In a large land mass like the Soviet Union the importance of flexibility in the provision of rural supplies needs no emphasis. The Soviet plan for 1956–60 calls for the building of more than 700000 km of h.v. and l.v. transmission lines for farm electrification together with more than 90000 consumer-supply transformer substations. Special attention has been devoted in the Union to the mechanization and standardization of power-station building. For hydroelectric stations these ideas involve dams made of prefabricated concrete blocks and standardized dams of various constructions. Prefabricated components for large power stations are manufactured on the construction site. It is claimed that these methods have reduced the cost of rural hydroelectric stations by 15–20% and cut down the time needed by from one-third to one-half.

Turning to utilization, drying produce with infra-red

rays seems to have received most attention in the Soviet Union where experiments have shown that the method uses 50% less fuel than drying by gas. Eastern Germany has had excellent results in the drying of hops. Poland has had success with bakers' yeast. Soya beans are made less bitter, and macaroni drying is encouraging. Carrots become so bright in colour as to look artificial. The radiation helps to conserve the active substances in medicinal herbs and kills the harmful microflora of plants. It accelerates the maturing of wines and improves their taste and bouquet. It is utilized for the determination of moisture content of agricultural produce and for its therapeutic effect on animals with chills and for encouraging growth.

Considerably more use is being made of electricity for grass drying, soil warming and soil sterilization. In Czechoslovakia mobile irrigation equipment is employed while electric ploughs, harrows and cultivators are applied on mountain fields and in pilot farms in Sweden, Switzerland and the Soviet Union. Sprinkling installations that generally operate at night are being introduced more and more widely in the Federal Republic of Germany and in the United Kingdom.

Electrically driven grinders and mixing machines for producing all livestock feeds on farms are finding greater acceptance in the United Kingdom and Ireland. Electrically produced heat has gained much ground in pig breeding especially in the preparation of pig food. Artificial lighting of hen houses has resulted in 15–30% more eggs. Reliable and inexpensive systems are available for the automatic air-conditioning of stables and sheds.

An examination was carried out of the economic advantages of rural electrification for which a number of countries supplied detailed evidence. The laconic comment of the United States was that electric power is regarded there as the cheapest for performing work which would otherwise require human or animal labour. Little attention had been paid therefore to computing the output, costs and savings obtained from utilizing electricity in agriculture. The practical British estimated savings in the automatic grinding and mixing of stock feed at £3 to £5 a ton or £250 to £400 a year on a medium-size dairy farm. The Russian Agricultural Science Research Institute calculated that each megawatt-hour used for agricultural processes was equivalent to about 350 man-days and 100 horse-days. They found that electrical sheep-shearing gave a 10% greater clip than hand shearing.

These random comments and extracts from the reports demonstrate what a kaleidoscope is presented by the varying practices in rural electrification in the countries of Europe. The wide diversity in conditions obtaining makes this disparity of practice inevitable; but it is nevertheless probable that such exchanges of information will, to use an agricultural metaphor, result in a significant cross-fertilization of ideas with a concomitant benefit for the Europe to which we in Britain, though somewhat reluctantly, are bound by geography, economics and common sense.

Pilot-scale γ-radiation processing factory

RESEARCH work by the United Kingdom Atomic Energy Authority on the commercial-scale use of intense radiation for industrial purposes has now reached the stage at which a pilot plant is being built for operation by the end of 1959. The factory is expected to be the first of its kind and size in the world.

It is being built at the Wantage radiation laboratories for the technological irradiation group of the isotope research division of the Atomic Energy Research Establishment. Study of the useful employment of the large quantities of radioactive material which will become available as a result of the nuclear power programme has been in progress for some years, and the new plant will enable industrial firms already investigating the technical merit and commercial potentialities of irradiated materials to carry out full-scale trial runs of irradiation processes such as the sterilization of medical equipment and the disinfestation of packaged products.

The entire installation occupies an area of approximately 10 000 ft², and this provides room for the storage of material both before and after processing and all the mechanical-handling equipment as well as the irradiation cell which takes up roughly 1000 ft² including massive concrete shielding walls. The factory is based on a unit package size of approximately 1 ft³, and parcels will be handled continuously and automatically from bulk store through the apparatus to the treated-material store.

To ensure full utilization of the capital investment, particularly of the source which is continually radiating and decaying, the plant will operate 24 h per day. Carefully designed interlocks and control devices are being incorporated to prevent any health hazard and to guarantee the correct radiation dosage.

The cell has been designed to house half a million curies of cobalt 60 but will be loaded initially with 150 000 curies which will provide a throughput of 7 Mrad-tons per day. As an example 3 tons of medical products or imported animal fibres could be rendered sterile in 24 h since a sterilizing dose is of the order of 2½ rads.

The engineering division at Harwell established the general design and specification of the factory to the requirements of the technological irradiation group.

There is another installation approaching completion near Melbourne, Australia, which is to be operated initially for the sterilization of goat's hair used in carpet making. It is a true production plant based on a design developed by the technological irradiation group, Wantage.

An electrical engineering review

Circuit trends in domestic sound and broadcast receivers

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In this article are considered the factors influencing the specification and design of modern broadcast receivers and radiogramophones with particular reference to the reception of frequency-modulated transmissions and the utilization of stereophonic long-playing records.

The application of commercially available transistors to receiver design is discussed, and anticipated future developments are studied.

The manufacture of printed-wiring laminate is described, and an assessment is made of the application of printed-wiring methods to receiver production. The bearing of such techniques on engineering design is briefly reviewed.
The author is with the Ferguson Radio Corporation.

F. A. RODWELL, B.SC.

In recent years there have been several incentives for radio designers to provide receivers having a higher order of fidelity than had previously been attempted. These incentives included the spread of f.m. transmitters throughout the country, the quality of reproduction from which is potentially superior to that from the amplitude-modulated transmissions available in the congested medium- and long-wave broadcast bands with respect to both frequency response and freedom from interference, and the introduction of long-playing vinyl records with a larger frequency response, greater dynamic range and lower surface noise than standard shellac discs.

The improvements in audio-amplifier design have invariably necessitated more-complex circuits, negative-feedback networks now being quite commonplace in all but the least-expensive domestic receivers.

While the electrical power output in general has not been greatly increased substantial improvements in the acoustic output have been made possible by the development of high-remanence and high-coercivity magnetic materials for the loudspeaker. Although the design of loudspeaker cones has shown much improvement recently many receivers are equipped with two, three and sometimes more separate loudspeaker units in order to achieve a better spatial distribution of sound and a smoother, extended frequency response.

Receiver r.f. sensitivities

Whereas the use of an external aerial is usually taken for granted in television reception the same outlook does not seem to apply to sound reception. Hence the design centre for receiver sensitivity is governed not only by the minimum field strength available in the various distribution areas but also by some reluctance on the part of the public to erect or make use of aerials external to the receiver.

It is now almost universal practice to have internal aerial facilities: for the broadcast bands a ferrite rod and for the v.h.f./f.m. band a shortened dipole. Inside buildings the field strength is liable to be reduced considerably, and input sensitivity on the f.m. band needs to be of the order of 2μV.

Standards covering design

The owner of a modern receiver must be protected by the conditions expressed in B.S. 415 (safety requirements) and 905 (interference characteristics) although there is no legislation to enforce their adoption. To comply with these Standards design must eliminate the risk of electric shock to the user or of an outbreak of fire in fault conditions and reduce to tolerable limits r.f. radiation from the receiver which might interfere with the operation of any communication service outside as well as inside the broadcast bands.

Radiogramophone design

The development by the recording companies of stereophonic discs has added a worthwhile dimension to the realism of recorded music. This is by no means a passing 'gimmick', and most future radiogramophones will include facilities for the reproduction of stereophonic sound.

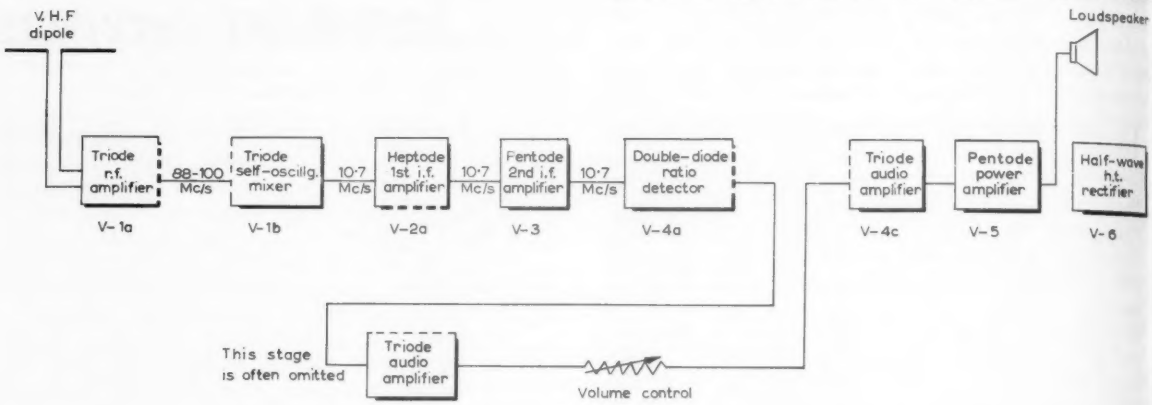
The discs carry two independent channels of audio information which can be reproduced simultaneously by a single stylus and which give two separate electrical outputs from the pick-up head. The separation of the channels is effected by stylus movements in two planes mutually at right angles and each disposed at 45° to the surface of the disc. The radiogramophone designer must therefore provide two independent audio amplifiers and two loudspeaker systems one of which may be contained within the radiogramophone cabinet and the other placed several yards away for optimum stereophonic effect.

The volume and tone controls for the two amplifiers can be either separate or preferably, for the convenience

of the user, ganged. Where ganged controls are used closer tolerances than have previously been available in the resistance law of the units are required to avoid acoustic unbalance at various settings. Additionally it is desirable to have incorporated some preset balancing device.

Basic circuit design

For mains-operated receivers there is a marked trend towards uniformity in basic circuit design among manufacturers in this country, particularly with regard to the selection of valve types. Excepting those radiogramophones having provision for stereophonic reproduction



1 *Valve functions in a typical 6-valve mains receiver switched to the v.h.f./f.m. band*

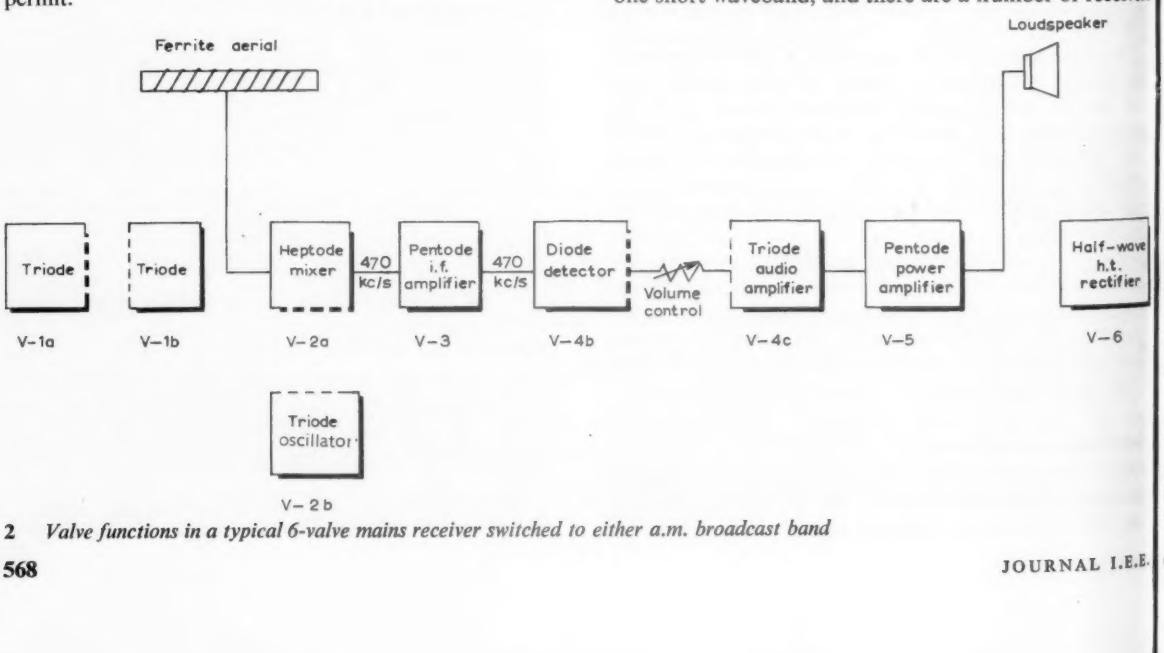
To reduce the cost involved in providing a second loudspeaker enclosure sufficiently large to reproduce adequately the lower frequencies a compromise solution is to combine the low-frequency outputs of the two channels in a speaker in the main cabinet and reproduce independently only the higher frequencies in small units placed at each side. This arrangement does not detract from the spatial realism of the performance.

In the larger radiogramophones adequate stereophonic effect can be realized by incorporating both speaker systems spaced as widely apart as cabinet dimensions permit.

the majority of receivers may be divided into these three basic types in terms of their waveband coverage:

1. Receivers for the medium and long broadcast bands (a.m.) and the v.h.f./f.m. band 2
2. The less expensive receivers for the a.m. broadcast band only
3. Export receivers for the medium waveband and two or more (depending on price) short wavebands covering frequencies up to 28 Mc/s.

A minority of receivers of type (1) include additionally one short waveband, and there are a number of receivers



2 *Valve functions in a typical 6-valve mains receiver switched to either a.m. broadcast band*

which cover only the v.h.f./f.m. band. The circuits in types (2) and (3) are basically the same except for the aerial and oscillator coil assemblies.

Most home-market receivers may be classified as type (1). Fig. 1 is a block schematic of a typical circuit when switched to the v.h.f./f.m. band while Fig. 2 shows the valve functions when switched to the broadcast band.

It is common practice to use a double triode in the v.h.f. tuner unit, the first triode usually operating as an earthed-grid r.f. amplifier and the second as a self-oscillating additive mixer having an i.f. output of 10·7 Mc/s.

The second valve is a triode heptode in which the triode section may be used as an additional a.f. amplifier on the f.m. band while the heptode section operates as the first i.f. amplifier on 10·7 Mc/s.

When switched to the broadcast band the triode maintains the local oscillator drive to the heptode section which is operating as a multiplicative mixer. The i.f. output is normally 470 kc/s.

Valve 3 is a pentode i.f. amplifier on all bands, the appropriate intermediate frequency being selected by the waveband switch.

Valve 4 is a triple-diode triode in which two diodes have the low impedance characteristics required for the f.m. detector, the third diode forms the 470 kc/s a.m. detector, and the triode is designed as a high-gain a.f. amplifier.

Valve 5 is a power pentode having an anode dissipation limit of about 12 watts and providing an a.f. power of up to 4 watts at the secondary of the output transformer.

Valve 6 is the h.t. rectifier which in receivers having an isolating mains transformer is often replaced by a contact-cooled selenium-bridge rectifier to reduce the size and cost of the transformer.

The f.m. demodulator is invariably of the ratio-detector type which has good a.m.-rejection properties even at low input levels. To use a Foster–Seeley discriminator it would be necessary to make the costly addition of an i.f. pentode valve to drive the limiter in order to obtain a performance comparable with that of the ratio detector.

Wide variations

Although uniformity is evident in the basic design wide variations appear in a more detailed analysis. Such variations are often a result of the different presentations required on the completed receiver. Among these may be mentioned piano-key-action waveband switches instead of the rotary type, combined or separate mechanical tuning controls for the f.m. and a.m. bands, and the inclusion of one, two or more tone-control devices.

Complex audio circuits are prominent among some receivers produced in Western Germany. A typical 'gimmick' consists of a piano-key switch to provide the optimum tone compensation for a variety of programme materials. These keys are marked 'jazz', 'orchestra', 'speech', etc.

Another detail variation not a function of presentation lies in the v.h.f. tuning system. Both inductive and capacitive tuning methods are used, but there is no marked trend favouring one system more than the other. The capacitive system is simpler mechanically and less expensive when combined with the a.m. tuning ganged capacitor. On the other hand oscillator radiation can more easily be kept to a low level with inductive tuning, especially with a grid-tuned oscillator.

Battery-operated receivers

No significant changes have occurred recently among battery-operated receivers using valves. It is common practice to carry both medium-wave and long-wave aerial coils on a ferrite rod followed by a conventional line-up of four valves having 25 mA heaters operating from a 1·5 volt dry cell. The valves include a heptode frequency-changer, a pentode i.f. amplifier, a diode pentode detector and a.f. amplifier, and a pentode output stage.

In mains/battery portables it is usual to operate the valve filaments in series from a 7·5 volt battery supply or on mains through a resistor from a single half-wave rectifier which also supplies the h.t. line of 90 volts.

Most manufacturers have introduced fully transistorized receivers alongside the lower-priced valve portables.

Transistors

It is in the field of transistors and other semiconductor devices that one may expect to see considerable developments in radio-receiver design. The transistor has aroused great interest since its invention was first announced in 1948. Whereas the first to be made were of the point-contact type in which two springy whiskers of wire press against a layer of semiconducting material the junction transistor is now much more widely used and is capable of handling far higher powers. In class B conditions output powers of 10 watts are available from units in push-pull.

The junction transistor consists essentially of a thin sandwich of two kinds of germanium-alloy crystal—negative or *n*-type and positive or *p*-type. The sandwich has three layers arranged either in the order *n–p–n* or in the order *p–n–p* with connecting wires to each layer.

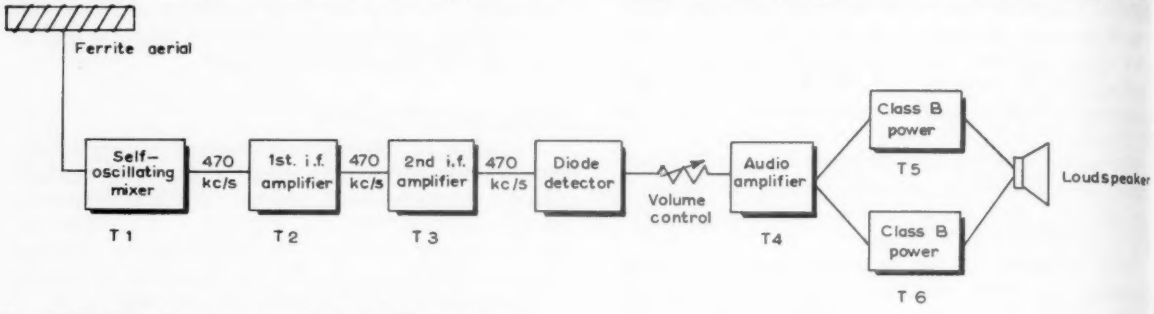
The two types of germanium result from the addition of minute quantities of impurity to pure germanium. If the impurity is gallium, indium, boron or aluminium the *p*-type is obtained while if arsenic, antimony or phosphorus is added the *n*-type is produced.

The transistor is well established in a.f. applications, and the recent past has seen the quantity production of types suitable for radio frequencies. Consequently a manufacturer can confidently produce transistor receivers covering the broadcast bands. As alloy-diffusion techniques advance the upper frequency limit is being raised, and already it is possible to base entirely on transistors

the design of export receivers covering the short wavebands.

A receiver of given performance uses more transistors than valves; for this reason and as a result of the higher unit cost of transistors the prime cost of a transistor receiver is much higher. However this high cost is partially offset by the advantage of battery economy and by the fact that such receivers are frequently made to use readily available torch cells.

In addition the electrical performance is unaffected by acceleration and vibration, i.e. transistors are completely non-microphonic. At present the spread in transistor parameters is much greater than for valves, and a fair comparison cannot yet be made as the latter have had so much longer to be developed and perfected.



3 *Application of six transistors in a portable receiver*

Typical transistor receiver

Fig. 3 is a block schematic of a typical six-transistor portable receiver having a power output of 200 mW and operated from a single 9 volt battery. The total current consumption varies from 9 to 20 mA according to power output.

The first transistor operates as a self-oscillating frequency-changer and is followed by two neutralized 470 kc/s i.f. amplifiers. The last i.f. transformer is matched into a low-impedance point-contact diode detector which also provides an automatic-gain-control bias for the first i.f. stage. The first audio amplifier follows the volume control and is loaded by a push-pull transformer driving the class B output stage of two power transistors. A development of these two transistors enables an output of up to 1 watt to be obtained. The limit is set by the rate at which heat generated within the junction can be conducted away.

The d.c. operating conditions of transistors are susceptible to temperature variation, and protection against 'thermal runaway' must be provided for each stage by some form of d.c. stabilization. This usually takes the form of a relatively low-impedance potentiometer providing a steady bias to the base while the emitter current is stabilized by a resistor. The resultant negative feedback which is effective for direct current is eliminated at signal frequencies by a by-pass condenser, and no loss of stage gain is incurred.

Fig. 4 shows a typical i.f. stage and indicates the d.c. stabilizing, the method of matching the input and output impedances of the transistor to the tuned circuit, and the neutralizing components necessary to offset the internal collector-to-base admittance of the transistor which is mainly capacitive. In this latter respect the transistor behaves similarly to an earthed-cathode triode amplifier although whereas the triode-grid input impedance is very high the base input impedance of the transistor is of the order of 1300 ohms shunted by 1000 pF.

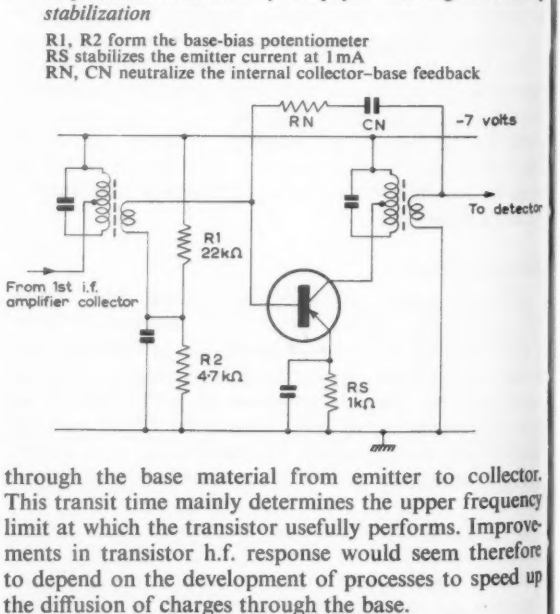
Transit time

The high effective input capacitance is for the most part a result of the slow transit time of a charge travelling through the base material from emitter to collector. This transit time mainly determines the upper frequency limit at which the transistor usefully performs. Improvements in transistor h.f. response would seem therefore to depend on the development of processes to speed up the diffusion of charges through the base.

In a typical r.f. transistor with an α cut-off frequency of 6 Mc/s the transit time is about 30 millimicrosec. With

4 *A practical transistor i.f. amplifier showing method of stabilization*

R1, R2 form the base-bias potentiometer
RS stabilizes the emitter current at 1 mA
RN, CN neutralize the internal collector–base feedback



an emitter current of −1 mA combined with a mutual conductance of 40 mA/V the effective input capacitance due to this transit time is 1200 pF. For the same transistor the actual base-to-emitter capacitance is only about 40 pF for equal base and emitter voltages, i.e. with the transistor cut off, while the collector-to-base capacitance is about 11 pF for a potential difference across this junction of −6 volts.

The operating potential is quoted because the capacitance across an alloy junction is voltage-dependent—a feature which although undesirable in this instance can be usefully exploited elsewhere. Later in this article an application of a junction diode is described.

Car radio receivers

To eliminate the need for a vibrator or rotary-generator h.t. supply a series of valves have been developed from the normal receiver type which will operate satisfactorily on the 12–14 volt h.t. supply from the car battery.

The audio amplifier which is incapable of a large output with this low voltage is used to drive a single transistor having a power output comparable with that in a normal receiver. This hybrid arrangement combines the stability and low noise level of valves with the efficiency of an audio power transistor and requires only 30% of the usual current from the battery.

Receiver-manufacturing techniques

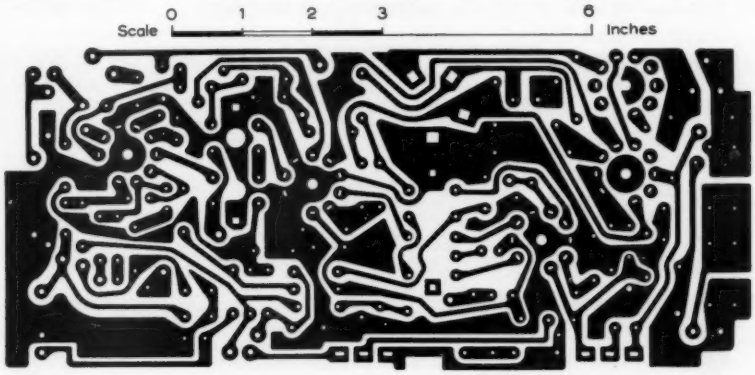
Until fairly recently it has been normal practice to build a receiver onto a shallow box-shaped steel chassis, the larger components being screwed or fixed with eyelets to the top face of the chassis, the smaller items anchored to tag strips underneath, and the whole assembly interconnected by an ungainly collection of tinned-copper wire and insulating sleeving.

By efficient assembly-line planning it has been possible to maintain a reasonably low level of production faults and fair tolerances in wiring lay-out though difficult to combat rising labour costs. Little opportunity has existed for the introduction of automatic processes other than conveyor-belt systems and automatic wire and component-lead cutters.

During the past few years however the development of printed-wiring techniques has offered new opportunities for economizing, particularly in the cost of labour for each receiver. The metal chassis is replaced by a laminated board pierced by holes through which the majority of the components are mounted, their leads terminating below the board in soldered joints to the two-dimensional copper wiring.

A printed board may be manufactured by several methods which are founded on two basic principles:

1. The printed-copper lay-out is built up by electrodeposition either directly onto the board or onto a separate metal carrier and subsequently transferred and bonded to the board
2. The printed wiring is obtained by starting with a board entirely covered by copper foil which is then selectively etched away to leave the required wiring.



5 *Printed-wiring pattern used for part of an a.m./f.m. receiver*

Method (1) is more complicated but has the advantage that less copper is required initially. If one starts with a pierced board copper can be deposited on the inner surface of the holes to provide stronger soldered joints to the components inserted.

Method (2) is more widely used and now that good-quality copper laminate is available is generally considered more economical. The manufacturing processes for this method are discussed below.

Selectively etched wiring

The production of the board itself can be almost entirely automatic. The starting material is a resin-bonded insulating laminate about 0·06 in. thick, to one face of which is bonded a sheet of copper less than 0·002 in. thick. The board is cropped to the correct size and after cleaning and degreasing an etch-resist pattern is applied to the copper face through a silk or metal screen. A typical pattern for part of an a.m./f.m. receiver is shown in Fig. 5.

After drying the exposed copper is etched completely away by an oxidation process using ferric chloride. The resist is then removed by solution, and after drying the board is ready for the hole-piercing operations. Finally a solder-resist pattern is screened onto the remaining copper to avoid wastage of solder in places other than those for component joints. A covering of flux protects the exposed copper from tarnish.

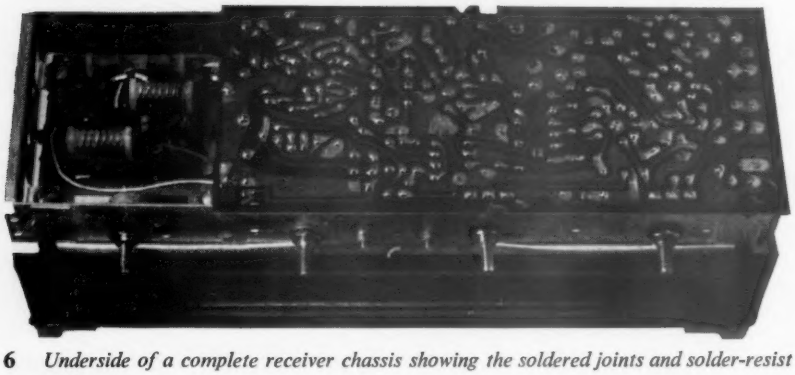
With this as a basis for a receiver one may note several advantages:

1. Accessibility and an orderly lay-out in one plane
2. Accurate reproduction of fixing-hole centres enables the manufacturer to buy components having leads pre-cut and formed ready for immediate insertion either by

hand or in the case of valve-holders, resistors and most capacitors by mechanical insertion heads on an automatic assembly line

3. The two-dimensional wiring simplifies soldering and offers the possibility of a simple automatic fluxing and soldering process

4. The lay-out facilitates visual inspection, and by means of a jig in which spring-loaded pins make contact with the underside of the board an electrical inspection can be quickly made by using a bridge method of comparison with a standard board, the information regarding faults being presented either sequentially or simultaneously on numbered indicator lamps. Such a 'routiner' can check for open- and short-circuit conditions and most of the component tolerances within a cycle time of about 20 sec.



6 *Underside of a complete receiver chassis showing the soldered joints and solder-resist pattern*

The disadvantages are:

1. It is often more difficult to avoid i.f.-amplifier instability and hum and noise in the audio amplifier

2. A temperature-dependent effect referred to later may detract from the merits of a printed board in certain applications.

Cost comparison

Although it is difficult to make a direct comparison between the metal-chassis and printed-board techniques the saving in cost of materials is negligible. With hand soldering there is a reduction in labour cost of about 20% which can be improved to 25% by the introduction of automatic soldering. This saving is quoted for the overall labour cost and includes coil winding, main line assembly, test and inspection, and final assembly. The greater part of the saving appears in the main line assembly.

In America where it has been possible to sell more than 5000 per week of a single type of printed-board receiver housed in a variety of cabinets large-scale automatic insertion of components can be economically justified. In this country however where such high production rates of one board are unlikely to find a sales outlet and where labour costs are by comparison lower, the high depreciation on an automatic assembly line together with maintenance costs make its introduction an uneconomic proposition.

Design more complex

The design of printed-wiring receivers is generally speaking more complex. Fortunately prototype boards can be made quickly from copper lay-out drawings by a photographic process, and measures taken to avoid hum, instability or other trouble can be readily checked in the development stages.

Unfortunately many of the laminates so far available have displayed a rather high and variable positive temperature coefficient for the capacitance between adjacent copper runs. One sample for instance showed a value of 4000 parts in 10^6 per deg C.

To offset this disadvantage there is inherent in the printed-wiring technique a reproducibility of lay-out which is particularly desirable at frequencies of the order of 100 Mc/s. However unless continuous batch testing can be provided and the appropriate temperature-compensation components introduced the laminate is less attractive as a basis for the v.h.f. tuner unit, and for this part of the circuit conventional techniques furnish a more compact and efficient assembly.

Parts of a modern receiver chassis covering the long, medium and v.h.f. broadcast bands are shown in Figs. 6 and 7. This receiver makes use of the printed circuit shown in Fig. 5.

Future trends

This could be called the transistor age so far as the history of radio is concerned. Only commercially available alloy-junction-type transistors have been referred to in this article. By an alloy-diffusion process these have been developed to operate at up to 30 Mc/s, and provided that production costs can be reduced the battery-operated valve receiver may well be displaced altogether from the home and export markets within the next few years.

A different manufacturing technique producing the surface-barrier transistor has already penetrated beyond 30 Mc/s, and further development may bring the f.m. band within the working range of these semiconductor devices.

Mention has been made of the capacitance/voltage relationship of an alloy-junction diode. The capacitance is roughly proportional to the inverse square root of the p.d. Consequently a junction diode forms a simple means of providing automatic frequency control on a

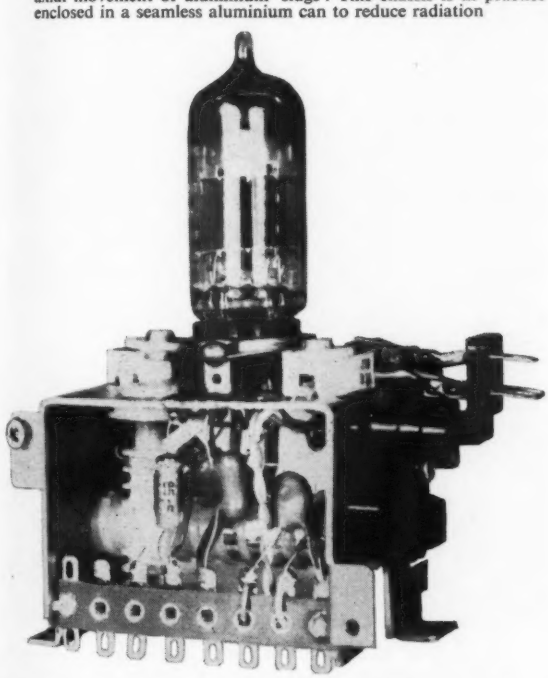
v.h.f. tuner unit when biased by the output from a balanced ratio detector. The introduction of this facility on domestic receivers would almost entirely remove the risk of distorted reproduction caused by initial mistuning of the f.m. band.

Reference has been made to stereophonic reproduction from records, and it is perhaps pertinent to consider the future possibility of broadcast stereophonic transmissions from a single v.h.f. transmitter. Such a system, like that advocated for colour television, would need to be compatible; i.e. it must permit normal non-stereo reproduction when received on existing single-channel equipment and provide full stereophony on receivers adapted to separate the two channels.

It is understood that the B.B.C. are at present studying a number of systems for radiating the two channels on one carrier frequency. Among these are a British technique employing a narrow-band control signal as the subcarrier and an American method in which the difference signals from the two channels are used to modulate a subcarrier. No definite plans have yet been made, but meanwhile the B.B.C. are checking public reaction to broadcast stereophony by further transmissions from two senders.

7 *Interior of an inductance-tuned v.h.f. unit*

The inductance of the horizontal copper-tape coils is varied by axial movement of aluminium 'slugs'. This chassis is in practice enclosed in a seamless aluminium can to reduce radiation



Summary

After about 35 years of development it might be expected that broadcast-receiver design procedure would be comfortably settled down if not near retirement, yet it is now passing through one of the most active phases in its history. Recent innovations such as v.h.f. frequency modulation and stereophonic reproduction have revealed hitherto-hidden facets of acoustic fidelity.

Simultaneously new fields have opened up for the application of semiconductors, primarily to battery portables but also extending to other receiver functions such as automatic frequency control. Notwithstanding a heavy purchase tax modern receivers can be made economically attractive to the public by good design combined with more accurate and reliable yet faster production techniques based on printed wiring and automatic electrical inspection.

Remotely controlled television camera

THE B.B.C. Television Service has taken over for experimental trial a remotely controlled television camera developed by the Engineering Division.

The camera is located in the All Souls television-interview studio near Broadcasting House, London, but all its functions —pan, tilt, focus, zoom and iris—can be controlled from the news studio at Alexandra Palace, about six miles away.

The camera proper is of the vidicon type and can be switched on from Alexandra Palace; it is then ready to operate within one minute. The camera tripod carries a special head in which the panning and tilting movements are operated by servo motors. Additional servo motors mounted on a plate fitted to the camera body are arranged to drive the focus, iris and zoom controls. The operation of the motors and their associated servo amplifiers is controlled over cable circuits from a special console at Alexandra Palace or by the interviewer in the studio who is provided with push-buttons for the purpose.

Apart from the console all the control equipment is at All Souls and is combined in a metal cabinet some 22 in. square and about 5 ft high. In addition to the power-supply equipment this cabinet houses the transistorized servo amplifiers, control relays and four additional sets of potentiometers for controlling the camera functions when under local control.

Local control is effected by using a set of four pushbuttons in a small box at the end of a trailing lead which in conjunction with changeover controls allow the camera to be operated locally, for example by an interviewer, to any one of four preset shots.

The interviewer by pressing the appropriate buttons can cause the camera to show himself and perhaps two other people in long-shot and then bring any one of the three people into close-up as required. The camera will pan and tilt as necessary, and for each shot the degree of pan, tilt, focus and zoom will be automatically adjusted to suit the particular situation. The 'shot-box' is small enough for the interviewer to hold comfortably in his hand; the trailing lead is sufficiently long to give him wide freedom of movement within the area which the camera has been set to cover.

Bringing water and power to Kuwait

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During recent years the general focus of attention on the Middle East has tended to be concentrated on the political situation and on the periodical crises that have arisen.

The great development taking place in the oil-rich countries has been somewhat overshadowed by other events, but it has nevertheless proceeded relatively unabated.

This account of a stage in the development programme of Kuwait is founded on a paper presented to the Iraq and Persian Gulf Joint Group. The author is with Ewbank and Partners Ltd.

D. W. SMART, ASSOCIATE MEMBER

It would be only with difficulty that a visitor to the present-day town of Kuwait with its dual-carriageway-roads, modern government buildings, blocks of offices, flats and elegant villas could conjure up an imaginary picture of what the town and its surroundings were like seven years ago. Standing in the north-west corner of the Persian Gulf and devoid even of adequate sources of potable water this desert town of 200000 inhabitants had until 1951 changed very little in its outward appearance during the previous 200 years of its history.

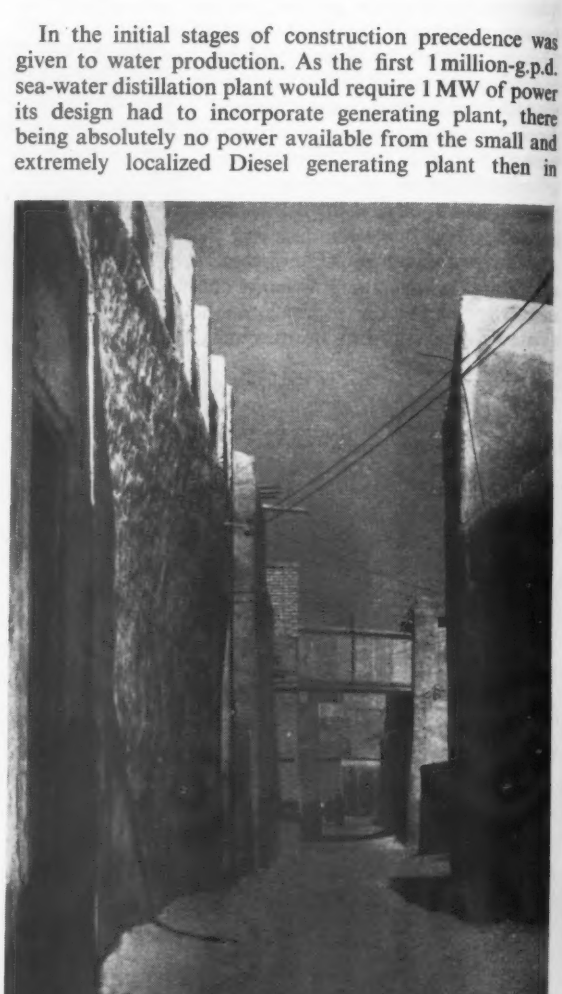
Previously dependent on sea trade and local pearling for its livelihood the small sheikhdom was suddenly endowed with comparatively tremendous financial assets accruing from the post-Second World War exploitation of its latent oil wealth. This resulted in a development programme being embarked on for which a comparison would be hard to find in terms of magnitude and speed of implementation.

Precedence given to water production

Water and power were the first necessities not only from the point of view of livelihood generally in Kuwait but also for meeting other requirements of the over-all development programme. The purpose of this article is to discuss a few of the electrical problems that arose in providing these two amenities.

At the present time Kuwait has sea-water distillation plant with a production capacity of 4 million g.p.d. of distillate and steam generating plant of 70 MW. Power is transmitted at 33 kV to one extremity of the town and to suburbs some seven miles from the town by oil-filled cable and overhead line; this 33 kV transmission system supplements an 11 kV underground distribution network which in the first five years of construction involved the building and equipping of some 77 substations and the laying of 120000 yd of 11 kV and pilot cable.

In the initial stages of construction precedence was given to water production. As the first 1 million-g.p.d. sea-water distillation plant would require 1 MW of power its design had to incorporate generating plant, there being absolutely no power available from the small and extremely localized Diesel generating plant then in operation. The generating plant was to consist of one 500 kW Diesel alternator set and three 600 kW turbo-alternator sets; the Diesel set was to be used for the initial start-up phase of the plant and thereafter as an emergency standby for the small steam sets.



1 *The type of street through which cables were laid and equipment moved during the initial stages of the 11 kV underground distribution*

In the early part of 1952 when plant began to arrive in Kuwait there were no docking facilities for vessels larger than dhows and barges, and larger shipping had to anchor some three to four miles out in the Bay of Kuwait and transfer their loads to the dismasted dhows, ex-military pontoons and barges which constituted the ship-to-shore method of transportation. Also at this time the maximum weight that could be handled by the local port authority was about five tons which immediately precluded the landing of a large proportion of the plant in the town of Kuwait.

Fortunately the Kuwait Oil Company had adequate handling facilities at their own port of Mina el Ahmadi, some 20 miles down the coast from Kuwait town. Frequent resort to these facilities had to be made, the plant then being transported by road to the site just outside the original Kuwait town perimeter.

2 *The harbour at Kuwait where most of the materials were off-loaded in the early part of the development programme*
Freighters lay off some three to four miles from this harbour

Plant-handling problems

Plant-handling facilities at the site were rather better than those of the Kuwait town port at this time, but with the time factor for ever shadowing operations there were occasions when equipment had to be lifted or moved at the site before the arrival of adequate handling gear.

An example of this was with the Diesel alternator set for the first distillation plant which weighed some 35 tons on its composite skid-type bedplate. It took five days to move this set 120ft including a 90° turn entailing the erection of a temporary bridge over some excavations and the improvisation of blocks and sheathing to give a 5-ton lifting block sufficient mechanical advantage to winch the set to its final position.

The handling of electrical plant continued to be a problem through all the phases of construction because although the town-port handling facilities continually improved, as building construction proceeded the weight of alternators and transformers in particular increased considerably which meant once more resorting to the handling facilities at Mina el Ahmadi.

Another problem that arose from ship-to-shore handling and which caused grave concern at the time was the arrival on site of some 11kV circuit-breakers which had been stowed upside down. The high ambient temperatures at the time had caused migration of compound from internal bushings with the result that the circuit-breakers had to be returned to the manufacturers to be made serviceable.

The packing-cases in question were marked quite clearly with the usual indications for correct stowage. To prevent a recurrence all packing-cases had to have special feet attached which made it difficult to stow them the wrong way up.

Start-up trouble

In March 1953 the first sea-water distillation plant was operational, and apart from the initial start-up phase when trouble was encountered in running up the boiler auxiliaries no major problems arose. The trouble experienced was due to the fact that manufacturers' delivery dates and the pressing time factor had necessitated the acceptance of motors with starting characteristics which did not conform to specifications.

With only 500kW from the Diesel alternator set available the starting currents of items like the boiler induced- and forced-draught fans proved too high, and a large amount of improvisation had to be carried out during starting-up periods until the small steam sets became operational, when the motor-starting characteristics ceased to cause difficulty.

Most of the electrical installation for the first sea-water distillation plant had been undertaken during the winter of 1952–53 when the climate was quite benevolent, but a great deal of thought had previously been given to the hazards likely to arise during the prolonged summer period. A Kuwait summer can last from April until October with extreme temperatures and frequent sandstorms. So in the early stages of operations in Kuwait, with a start still to be made on a 30MW power station and an 11kV underground distribution network, an endeavour was made to anticipate any difficulties the future might hold.

Sweated joints!

The straight-through jointing of 11kV cables was the first point to be given consideration. During the midsummer of 1952 it was decided to begin the first stage of the underground distribution network in an effort to provide some power for the inhabited parts of the town

perimeter from the existing rapidly expanding Diesel generating station.

This necessitated the laying and jointing of some 4000 yd of 3-core 0·25 in.^{2} 11 kV cable with local climatic conditions at their worst. The first hazard to be studied was that of perspiration from the cable jointer and his assistants. With an average time of six hours to complete a joint in a shade temperature of 120° F it would be impossible to guarantee that the insulation of the conductors being jointed had not been contaminated by perspiration.

3 *View from the sea of the sea-water intake jetties for 'A' and 'B' stations and (from left to right) the turbine houses of station 'B', station 'A' and distillation plant 'A'*

As a counter to this hazard a patent type of impregnated-paper roll the application of which entailed the handling of the outer layer only was used for insulating the jointed conductors. The likelihood of contamination from perspiration was therefore reduced to a minimum. The advisability of using this type of insulation was proved at a later date in an investigation of the failure of an 11 kV straight-through joint where the standard type of rolls of insulation which have to be handled continuously during their application had been used. The investigation indicated that with the exception of the possibility of faulty application of some of the insulation the failure was due to contamination.

Keeping out the sand

The second hazard to be examined was that of the sudden onset of a sand-storm with an 11 kV straight-through joint at a stage of partial completion. Anyone who has experienced the type of sand-storm that is encountered in Arabia will appreciate that short of hermetic sealing it is impossible to prevent the ingress of sand particles into an enclosed space. The removal of sand particles once they had come into contact with the sticky jointing materials would be impossible, and the completion of a joint in these conditions would be tantamount to providing built-in potential faults with each finished joint.

To try to seal a cable-jointers' tent in the shade temperatures experienced would only make the already onerous working conditions impossible. The only feasible solution appeared to be in developing a technique for applying a non-adhesive protective wrapping to the exposed joint which could be removed when the sand-storm subsided, extreme care being exercised during the removal of the wrapping to prevent any of the sand particles which might have adhered to it from being deposited on the exposed joint.

The ultimate solution proved completely different from that conjectured. A more than normal quota of sand-storms during the early summer of 1952 brought to light the fact that although they varied somewhat in duration their starting times were remarkably constant, namely between 10 and 11 a.m. and between 2 and 3 p.m. Arrangements were therefore made for jointing to begin at dawn whereby a joint had reached a stage of immunity by the usual starting time of a sand-storm.

Occasional periods of very high humidity with a relatively high ambient temperature had also to be contended with, but the local climatic indications normally gave fair warning when these conditions were likely to arise and all h.t. jointing operations were suspended.

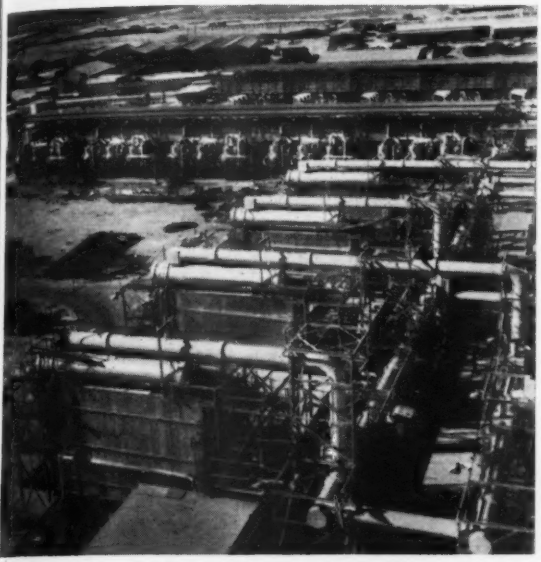
In February 1953 construction of the 30 MW steam power station began. Following the completion of its commissioning in June 1955 work was started on a 40 MW extension the fourth 10 MW set of which was commissioned in December 1958. The ship-to-shore handling of major items of electrical plant once more necessitated the use of the oil company's facilities. But conditions on site had been considerably improved, and apart from having to design and fabricate a special derrick on site to lift the main fabricated beams of the turbine-house crane for the 40 MW extension the plant handling gave no serious difficulties.

A critical period

The critical period for the electrical installations for both stations arose during the summer months. In the case of the 30 MW station the summer of 1954 provided more than the normal quota of times of high relative humidity. During these periods all h.t.-cable jointing and terminating was suspended. It was also found inadvisable to leave any paper-insulated cable unsealed, even for a very short time, when the relative humidity was high.

The termination of m.i.c.c. cables was occasionally

suspended mainly because the insulation-resistance testing instruments became so saturated with moisture that only very low readings could be obtained even with the instruments disconnected. One was never sure therefore just how much moisture the extremely hygroscopic insulant had absorbed before the termination of a cable was complete.



4 *In the foreground are shown 4 × 500000 g.p.d. evaporator units; immediately behind are 5 × 100000 g.p.d. evaporator units of distillation plant 'B'; and behind them are 5 × 100000 g.p.d. evaporators of distillation plant 'A'*

In the case of the 40 MW station the summer of 1957 was somewhat more lenient in respect of periods of high relative humidity. But the spark-gap of an 80 kV test set used for pressure-testing the 33 kV equipment proved most unstable when the relative humidity exceeded 45% with ambient temperatures of 110° F or above.

During the filling and initial charging and discharging of a 115-cell battery used for the solenoid-operated 750 MVA 33 kV switchgear and contactors of all the major auxiliaries it was found that the ambient temperature of the battery room was only 2° F below the maximum temperature the manufacturers recommended the battery should be allowed to attain. It was impossible to prevent the temperature of the battery exceeding the maximum recommended temperature on several occasions during these operations, but the battery has apparently suffered no ill effect. As a future safeguard however the battery room has been air-conditioned.

Summary

The few problems discussed can be summarily grouped under plant handling and climate.

The rate at which plant-handling problems were overcome was primarily governed by the availability of handling equipment from manufacturers and the improvement of ship-to-shore transportation and delivery facilities.

The climate is a perennial problem, and local experience is the most useful asset in anticipating the difficulties likely to be encountered.

FIRST INTERNATIONAL STAFF JOIN 'DRAGON'

THREE engineers, one from Switzerland and two from Italy, arrived in Britain on the 21st September 1959 as the advance guard of some 90 European engineers and scientists who with 160 from the United Kingdom will comprise the international staff of the O.E.E.C. Dragon project at the Atomic Energy Establishment, Winfrith, Dorset.

The aim of the project is to develop and build an experimental version of the high-temperature gas-cooled reactor. The Dragon agreement was signed in Paris on the 23rd March 1959 by the United Kingdom Atomic Energy Authority, the Commission of the European Atomic Energy Community Euratom through which Belgium, France, Italy, Luxembourg, the Netherlands and West Germany will participate, the Governments of Austria and Switzerland, and the national atomic energy organizations of Denmark, Norway and Sweden.

Recently Dr. Sigvard Eklund of Sweden was elected chairman of the international board of management. Sir William Penney is vice-chairman. Dr. J. Gueron of Euratom is chairman of the Dragon general purposes committee, and the chief executive of the project is Mr. C. A. Rennie of the U.K.A.E.A.

This is the third joint project under the auspices of the European Nuclear Energy Agency of the O.E.E.C. It is the second in which the United Kingdom is participating and the first for which Britain is the host country.

Already nearing completion at Winfrith is the Authority's zero-energy reactor Zenith which will make an important contribution to the programme. It is designed for the reactor-physics studies for the high-temperature gas-cooled concept and will operate in temperature conditions similar to those in Dragon. The heat in Zenith however is supplied by electrical means not by nuclear energy since the heat from fission will be only a few hundred watts.

This new type of reactor introduces principles which have not yet been tried experimentally. Hence the aim of the joint project is to lay a firm foundation for the reactor technology of these systems on which future developments can be securely based. The reactor will have an operating temperature in the region of 1000° C, and its capital construction cost is expected to be relatively low. It is hoped that nuclear power stations based on this reactor system would generate electricity at prices similar to those of electricity from coal- or oil-fired plant in most conditions of power supply.

WOMEN IN ENGINEERING

On the 2nd April 1959 at an Ordinary Meeting of The Institution at Savoy Place a discussion took place on 'Women in engineering' centred on a report issued by a committee set up under the auspices of the Manchester College of Science and Technology. The President, Mr. S. E. Goodall, was in the chair.

Why are there so few?

Sir Willis Jackson opened by referring to the three broad categories of people in industry: the professional group, technicians and manual workers. Many women were in the third category, but they would not be included in the discussion. Discussion of women in the professional group must however inevitably overlap with that of the woman technician.

It was necessary to consider engineering appointments for women which required an appropriate technical qualification and training and as such would impose on women as severe an intellectual discipline as is accepted by the corresponding classes of men. Although the topic of the discussion was women in engineering he felt it wise to include those engaged in the broad scientific and associated technological fields in view of the growing interdependence of progress in engineering on advances in mathematics, physics, chemistry and metallurgy.

He gave the audience these facts:

Table 1. First degree or diploma in science and technology awarded by U.K. universities in 1957

	Men	*Women*
Honours in mathematics	343	126
physics	548	58
chemistry	735	71
other science subjects	627	281
General honours degrees	228	83
Pass degrees	508	267
Total	2989	886
Technology	2265	9

Table 2. National Certificates awarded in 1958

	Men	*Women*
Electrical engineering		
Ordinary National	4239	16
Higher National	2157	4
Physics		
Ordinary National	364	41
Higher National	153	16

The Tables show that the number of girls pursuing systematic courses of education and training in technology is extremely small. Why? Is it because industry feels that for women the training period is too long compared with the short period of responsible employment which could be expected owing to the present-day tendency for earlier marriages; is it that industry considers women innately unsuitable to occupy positions of responsibility in competition with men; or is it that industry has not given sufficient expression to its willingness to encourage worthwhile girls to undergo systematic education and training?

Is engineering a wise choice?

Sir Willis turning to the subject of women scientists analysed Table 1 and pointed out that the number of women honours mathematics graduates was about one-third of that of men, of honours physics only 10%, of honours chemistry only 10%, and of other science subjects about 50%. Of 126 women honours mathematics graduates, more than 50% took up teaching in one form or another and only 31% entered industry and commerce. Of 58 physicists only 19% adopted school or university teaching. In honours chemistry only 14% became teachers.

Sir Willis Jackson opens the discussion

He wondered whether it was really wise nationally to encourage girls with an aptitude for mathematics, physics and chemistry to take up engineering rather than continue with their further studies in science.

Miss Anne Shaw who was chairman of the Manchester committee which produced the report recalled that in 1935

the Women's Engineering Society had 30 members, who could be compared with the 111 women members of the three major institutions today. This increase in about 20 years was highly encouraging.

Women should think of a career not as a job to be performed until marriage but as something which could be continued after marriage. Her experience led her to believe that there were always a few women who had a vocational drive and who made first-class engineers, given a suitable opportunity, because in general they worked harder and the fact that they faced many difficulties associated with a career and marriage ensured that only the best type of girl was involved.

Referring to Sir Willis's opening remarks she suggested that girls interested in science should be encouraged to enter the teaching profession in order to raise the standard of science teaching in girls' schools. Teaching was one of the best careers for combining with marriage.

To limit or not

Mr. T. E. Goldup,* PAST-PRESIDENT, felt that engineering was not an attractive career for women. He spoke enthusiastically of his experience during the recent war when Wrens working on the servicing of radio equipment showed surprising aptitude and ability. While seeing great opportunities for women in laboratories and technical libraries he expressed grave doubts regarding their employment in manufacturing industry. There were limits to the type of task a woman could be asked to undertake.

Miss M. M. Nobbs, President of the Women's Engineering Society, crossed swords with Mr. Goldup concerning the use of women in manufacturing industry. She would admit no limit to the type of work which they could do provided that they were adequately trained. She felt strongly on the question of good teaching of the right subjects in girls' schools. Professional women who had retired from work could be reabsorbed in this kind of occupation.

She made interesting comparisons between the results of the Manchester report and those obtained by the Women's Engineering Society from a questionary to test the willingness of industry to train girls. Of 640 firms only 160 replied, and of these 90 considered the work unsuitable for women, 13 had no training schemes, six employed girl graduates, 21 had student apprentices under training, and a further 24 not yet involved were willing to consider suitable girls when the opportunity arose. It appeared that industry was willing to give girls an opportunity of training.

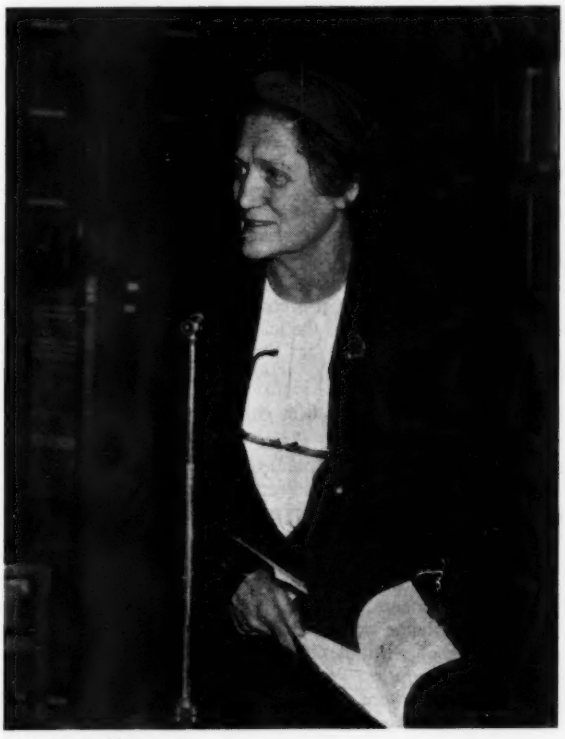
The profession of medicine might have greater attractions for humanitarian reasons, but it was important that girls should be given an opportunity and should be encouraged at school to focus their attention on careers in science and engineering.

How to assess ability

Mr. H. West, an employer of professional women engineers over the last 30 years, said that they had enough experience to know that intellectually men and women were equal even in the subject of engineering. One of the chief difficulties in employing women was the unprejudiced assessment of their ability.

His experience with the Ministry of Labour in the Manchester area during the 1939–45 War indicated that at school level there was a small percentage of girls definitely interested in engineering. The great problem was to locate those particular girls. The present systems indicated which girls were good at mathematics and physics but gave no opportunity of determining the girls' interest in technical matters.

There should be similar training for girls as existed for boys; where this was made available the keen and able girl would stand up to comparison with men of similar ability in all classes of engineering work.



Miss Anne Shaw

Councillor Kathleen Ollerenshaw, a mathematician and a member of the committee responsible for the Manchester report, agreed that girls were capable of making a considerable contribution in research, in development design, and even in management and sales.

The present trend towards earlier marriages meant that the most that employers could reasonably expect from the average girl was about seven years' full-time work including the period of training. Women in general did not find full-time employment in industry compatible with married life.

Three snags arose when a girl chose engineering as a career. First, because of the small number of firms interested she probably found her occupation was far from her home; secondly the career did not lend itself to the earning of money casually as an adjunct to married life; and thirdly the profession did not offer sufficient flexibility to a young woman who after marriage often had to settle down with her husband in an area where there was not much opportunity. Industry ought to consider part-time facilities for professional women and better holiday arrangements.

*As we go to press we learn with deep regret of the death of Mr. Goldup on the 6th October. An obituary will be published in due course.

Dr. H. L. Haslegrave who is concerned with an educational institution for engineers somewhat facetiously referred to the desirability of increasing the number of girl students at technical colleges in order to give the young men studying engineering better facilities for companionship with women who are socially and intellectually their equals. He referred to the great loss during and after professional training owing to girls marrying and forsaking technical interests.

The best field of application for women in engineering was probably in the technician grade where a higher course of training at a technical college and in industry would probably be worth while and enable the girls to make a reasonable contribution before they married.

Engineering an uncultured occupation?

Miss Helen MacNair, a professional chemist with the Admiralty, spoke of the opportunities in the scientific civil service which might appeal to women and pointed out that there were no special restrictions in regard to recruitment. The proportion of women was probably 25–30% in the technical grades, 16% in the higher grades, but at principal scientific officer level only 1–2%.

The relative scarcity of girls coming forward for engineering careers was largely due to the lack of satisfactory teaching in girls' schools and to the fact that many headmistresses felt that engineering was an uncultured job.

Dr. K. R. Sturley of the B.B.C. Education Branch referred to the problems of selection. Most recruiting officers if offered men and women of equal qualifications and equally attractive personality would in almost every case choose the men. The small return in terms of years of service and the general belief that women could not exercise professional control over men were the deciding factors. He agreed that schools and universities did not do enough to encourage women to take up an engineering career.

In his experience women graduates were accepted by their male colleagues without distinction, but this was not so in the technician grades. Women were better than men where dull routine jobs were concerned: they were tidy, made good operatives and in general were most trustworthy. They were less praiseworthy in regard to temperament and attendance. While wishing to encourage women engineers he felt that the best prospect for women in industry was in the technician grades.

More practical training

Mrs. C. Robinson, a transformer designer with an industrial company, gave the views of a young woman who had recently entered the profession by means of a sandwich course at the Royal Salford Technical College and a student apprenticeship with one of the leading electrical firms. She spoke of the difficulty of obtaining employment when compelled to move to another district as the result of marriage.

She referred to her experience at one of the leading girls' day schools in the country, paying tribute to the education she received in mathematics but referring to the training in physics as being satisfactory but not particularly practical. Girls should be encouraged to go in for more practical and technical training. She had experienced opposition in her school when it became known she was choosing engineering as a career. This opposition arose largely from a misunderstanding of what was required of women in engineering which was considered a dirty, noisy and far too heavy job for a woman.

She had found the training in her sandwich course satisfactory for whereas most boys took to practical work easily girls found it difficult, and the combination of theoretical training at the college and practical experience at the works was in her opinion a great advantage for women. She had found her work in a large firm on the north-east coast satisfying and had experienced no difficulty in being accepted by her male colleagues.

Dr. W. J. Gibbs appreciated the contribution which women could make in engineering, but he had some unhappy comparisons to make of men and women in regard to effective employment.

In his company the average length of service of male engineers was about 20 years, whereas for professional women the service was only 2¾ years after which they generally left the profession. Men on the other hand were generally associated with industry until retirement.

Councillor Kathleen Ollerenshaw

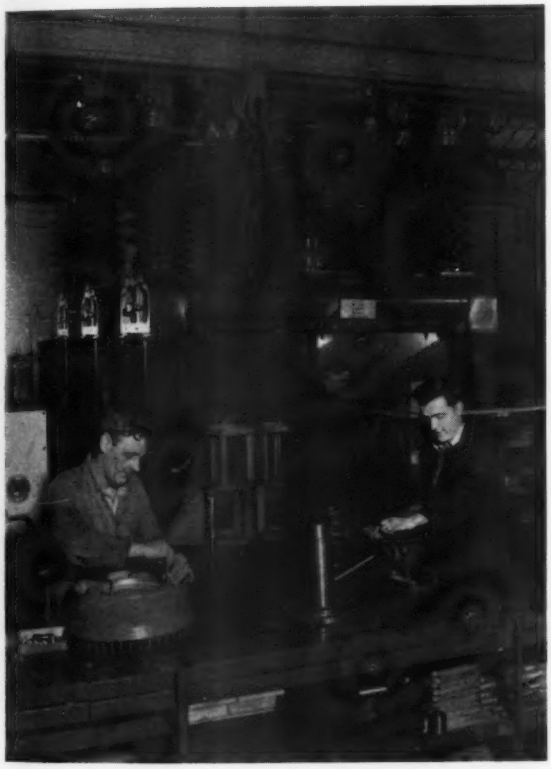
He did not believe it possible for professional women to return to industry after raising a family, but a return to teaching would be of great advantage. He was rather afraid that in a few years' time when opportunities for training might be more limited than they were at the moment owing to market conditions, industry would be faced with the fact that in choosing a woman for training they were keeping out a man.

Colossal ignorance

Mrs. I. H. Hardwich, also a member of the committee which drew up the Manchester report, pointed out that in general deductions drawn from the present situation so far as women were concerned were unreliable as they could only be based on individual cases. If there were one or two thousand women engineers the whole situation would take on a different aspect. She mentioned her propaganda efforts in connection with schools and the work which the Women's Engineering Society was doing in approaching parents, teachers and girls through the schools' careers conventions and conferences.

She spoke of the colossal ignorance and the prejudice of employers and said that large numbers of women would not be attracted until some progress had been made in that direction.

Several speakers had mentioned the wastage due to marriage among girl trainees, but for other reasons there was wastage among boys which was not generally referred to.



A girl apprentice at work on a 132 kV air-blast circuit-breaker (left background)

Her chief desire was to see women accepted on an equal basis with men in shop-floor management.

Mr. A. B. Calkin said that his company employed women in all branches of scientific activity and in the production organization on development design, on the analytical control of materials, on works study, on technical writing and on laboratory services.

Of a total requirement of 92 at the beginning of 1959 for graduate scientists and engineers 40% of the vacancies had been declared suitable for women. Of candidates interviewed only 7·4% had been women.

The highest positions were open to women. The average period of service was of the order of 6½ years. Women were preferred for chemical analysis and quality control in valve measurement laboratories because they exhibited great patience and attention to detail. He did not think that women would be considered for posts in management and supervisory control unless there was a distinct shortage of suitable men.

Women showed up badly at interviews in comparison with men. They showed a sad lack of motivation and very little knowledge of industrial conditions. His company was definitely supporting equal opportunity for women in a large variety of jobs.

The present low percentages were entirely due to the lack of candidates, and with time and the employment of more women the prejudice against them in a large range of posts would be overcome.

A more balanced view

Mr. C. J. O. Garrard's experience led him to believe that women took a much more balanced view of the values of life than did men. Peace, beauty and true creation in the home and family were their outstanding contributions. Women would always make great contributions in emergency conditions, but fundamentally women did not enter the engineering industry as they felt it to be primarily a field for men.

Sir Willis Jackson summed up the discussion very ably and said that during the past two years his firm had included girls, to the extent of about 30%, in a fortnight's Easter-vacation course at the works intended primarily for fifth-form boys.

The girls had been found to be very interested in this experience and had evidently appreciated the opportunity of gaining an insight into engineering work.

So far as he knew none of them had decided to study engineering, and indeed at this stage he would prefer them to concentrate on physics, chemistry or mathematics with a view to entering industry as scientists if they were disinclined to follow teaching careers in those subjects. If however any of them chose engineering he would hope to be able to help them to obtain satisfactory training. H. W.

WOMEN GRADUATES IN THE U.S.A.

RESULTS recently published of a survey of first jobs of 88 000 women graduating in June 1957 in the United States show that a small percentage proceeded to graduate work either full- or part-time, principally in education. Teaching was also the most popular calling of the employed graduates, 42 000 joining the profession.

In the social, physical and biological sciences and in mathematics and engineering however, where many excellent opportunities are stated to exist for women graduates, the numbers were disappointing. Only 586 women took posts as chemists and 703 as mathematicians and statisticians, or 1·8% of the employed graduates.

The sagacious Mr. Cavendish

92(Cavendish):621.3.011

The author of this article is no 'debunker' of the great. He prefers to seek the man behind the mists of the past and if he likes what he finds, to write about him. This is the story of 'the most accomplished British philosopher of his time' whose 'work put an end to the electrical dark ages'.

Mr Hammond is in the Department of Engineering, University of Cambridge.

P. HAMMOND, M.A., ASSOCIATE MEMBER

WILLIAM Thomson who later became Lord Kelvin knew a good thing when he saw one. While he was still at the university at Cambridge a friend showed him Green's essay on electricity and magnetism. At once he realized its value, and within a year his enthusiasm had brought it about that Green the obscure miller from Nottingham had become recognized as a natural philosopher of the highest rank. Green had died four years before this, but although he did not enjoy his triumph his work at least was honoured through Thomson's advocacy.

A great discovery

In 1849, four years after his discovery of Green, William Thomson made an even greater discovery. He records in his notebook: 'Sir William Snow Harris has been showing me Cavendish's unpublished manuscripts . . . I find already that the capacity of a disc (circular) was determined experimentally by Cavendish as 1/1·57 of that of a sphere of the same radius. Now we have capacity of disc $= \frac{2}{\pi}a = \frac{a}{1 \cdot 571}$! It is much to be desired that those manuscripts of Cavendish should be published complete; or, at all events, that their safe keeping and accessibility should be secured to the world.'

Small wonder that Thomson put an exclamation mark in his notebook. That accurate measurement of capacity had been made about 1770 when scientists were still discussing whether electricity was an influence or atmosphere or whether there were one or two electric fluids. Moreover the only measuring device available to Cavendish had been a pith-ball electroscope and the only source of electricity a friction machine.

What was even more surprising was that these manuscripts contained an experimental verification of Coulomb's law, Ohm's law and Faraday's work on dielectric constants; and all this was the work of a man who was known to his contemporaries primarily as a chemist! William Thomson pressed for publication, and in 1874 Clerk Maxwell was persuaded to edit Cavendish's electrical papers. They were published in 1897 about 100 years after they had been written.

Henry Cavendish the man

Who was this remarkable author who cared so little for fame that he did not trouble to publish researches that would have been sufficient to make the reputation of a dozen great men of science? The Honourable Henry Cavendish was born in 1731. His paternal grandfather was Duke of Devonshire, his mother's father Duke of Kent. His mother died when he was two years old, and he never married.

Henry Cavendish

This is apparently the only portrait in existence. It was probably done from sketches made by W. Alexander at a dinner of the Royal Society club without Cavendish's knowledge

He went to school at Hackney, spent three years at Cambridge, but did not take a degree. He was elected a Fellow of the Royal Society in 1760 and contributed 12 papers to its *Philosophical Transactions*. Up to the age of 40 he was relatively poor and used to arrive at the dinners of the Royal Society dining club with exactly the right amount and not a penny more in his pocket. But as a result of legacies received, when he died in 1810 he was worth more than £700000.

These few facts are about all that is known of Cavendish's life. He lived alone, he worked alone and he died alone. He had not a single close friend, and yet he had the acquaintance of many good and learned men who admired his vast learning. What was it that made him so queer? We are not the first to ask this question.

His neighbours at Clapham wondered, and some came out to observe him on his daily walk. Poor Cavendish began to take his walk after dusk. The truth was that he was just very, very shy. Tall and thin, with a squeaky voice and a nervous manner, he hated to be noticed by anyone.

A typical incident occurred when a foreign gentleman was introduced to him at a scientific meeting. The foreign gentleman began to compliment Cavendish as one of the greatest ornaments of the age and one of the most illustrious philosophers that ever existed. 'To all these high-flown speeches Mr. Cavendish answered not a word, but stood with his eyes cast down, quite abashed and confounded. At last spying an opening in the crowd, he darted through it with all the speed of which he was master, nor did he stop till he reached his carriage, which drove him directly home.'

New Fellows of the Royal Society who wanted to talk to Cavendish were given these directions: 'never look at him, but talk as it were into a vacancy, and then it is not unlikely but you may set him going.' When he was 'set going' he always spoke exceedingly to the purpose 'and either brought some excellent information or drew some important conclusion. His knowledge was very extensive and very accurate.'

'*A wonderful piece of intellectual clockwork*'

'Accurate' is a word that meant everything to Cavendish. He did not discuss natural phenomena in general terms, he measured them. This is what attracted Lord Kelvin's attention, and this is what Clerk Maxwell found when he edited Cavendish's electrical manuscripts. His contemporaries knew a little of his care as an experimenter. They knew of the amazing series of experiments on the density of the earth in which Cavendish used a torsion balance. Then there was the published account of an extensive series of experiments on the synthesis of nitric acid.

But Cavendish published only a fraction of his work, and none of his contemporaries had the slightest impression of his patience and immense skill in the measurement of electrical effects.

Just one example will have to suffice. Cavendish states in one of his published papers that iron wire conducts about 400 million times better than rain-water, but he does not say how he arrived at such a result. How did he do it without a galvanometer and without a source of constant voltage? *Simply* by connecting himself as a part of a series-parallel circuit and testing the strength of the electric shocks obtained from a condenser. It was by this means that he verified Ohm's law—just about 50 years before Ohm.

To many people Cavendish's passion for measurement must seem nothing but an obsession. Why did he calculate the height of the northern lights rather than observe their beauty? Why did he measure the barometric pressure on top of a hill rather than admire the view? Why did he hang up his hat always on the same peg and put his walking-stick always into the same boot? We can only guess, but is it likely that he did it to reduce the number of variables in the equations of life. What he wanted above all was consistency in his results. To his biographer he appeared as a man without feeling: 'a wonderful piece of intellectual clockwork.'

A natural philosopher

Such a view of Cavendish may have been reasonable before Lord Kelvin first saw the unpublished manuscripts and before Maxwell edited and annotated them. But Lord Kelvin would not have been so enthusiastic nor would Maxwell have devoted so much of the last five years of his short life to Cavendish's work if Cavendish had been no more than a human computing engine. From Maxwell's minute and brilliant analysis of his work a different and far greater Cavendish emerges.

In his chemical researches it is perhaps true that his chief contribution was accurate measurement, but what was a man to measure in electricity in 1770? It was not only that there were no measuring instruments except the pith-ball electroscope but above all there was nothing to measure. It was not only that there were hardly any sources of electricity available to the experimenter; the real trouble was that electricity had not been invented at all. There was neither electric charge nor current, neither voltage nor force, neither resistance nor capacitance, only torrents of words about fluids and atmospheres and electrical influences.

Among all this confusion we see the solitary figure of Cavendish clearing the way by careful definition of concepts, by hypothesis and by painstaking experimental verification. He defined charge and potential

difference (called by him degree of electrification), capacitance, resistance and current density.

The keystone of electrical science

His masterpiece is the verification of the inverse-square law now known as Coulomb's law. Coulomb did his work some 15 years after Cavendish and cannot have known of Cavendish's unpublished work. Coulomb used a torsion balance, and he deserves high praise for the accuracy and ingenuity of his work.

But Cavendish's method is immensely more powerful. He did not measure the force direct but deduced that if it varied as the inverse square of the distance there would be no force inside a hollow charged sphere. With an apparatus costing a few shillings—'more complicated than was necessary' he confides to his notebook—he showed that the force must vary inversely as $2 \pm \frac{1}{50}$. Maxwell using a very similar method was able to show that the index must be $2 \pm \frac{1}{72\,000}$.

With this experiment Cavendish put the keystone of electrical science firmly into its place. His work put an end to the electrical 'dark ages'.

Conclusion

Why then did Cavendish keep the world waiting instead of announcing his tremendously important results? Once again we can only guess. He was shy and lonely. Would anybody have understood his thoughts on electricity at the time? Or would they have argued with him and made life a burden and work an impossibility?

There was so much work to be done, and time was passing. It was time to get on with some work, and Henry Cavendish shut the front door of his house and walked towards his laboratory. 'What do you wish for dinner, sir?' inquired the housekeeper. 'Leg of mutton of course, why do you trouble me?' shrieked Cavendish at him. 'Why cannot people be more methodical' he grumbled, and *bang* went his laboratory door to shut out all possible variables such as housekeepers.

'A great brain and a very small man' writes a modern author 'a psychiatrist might find it interesting to guess at the early experiences which made full human development impossible.'

Perhaps so, but one prefers the opinion of Sir Humphry Davy who knew Cavendish as an old man: 'He was acute, sagacious and profound and I think the most accomplished British philosopher of his time.'

DRIVERLESS FARM TRACTORS

Some people think that with such a machine as is described here thousands of man-hours could be saved on big arable farms where routine cultivation jobs have to be done three or four times a year.

RECENTLY there were numerous references in the national Press and more particularly in the agricultural Press to a demonstration at the Reading University Farm of an automatically controlled tractor. This was staged jointly by the farm-mechanization department of the University and the rural-electrification section of the British Electrical and Allied Industries Research Association. Although the principles involved were not new it is believed that this was the first time anywhere that a driverless tractor had been seen performing a number of preselected agricultural tasks.

Objects of the exercise

The two principal objectives of the project were:

1. To see what technical snags there might be in equipping a tractor for such a demonstration
2. To sound agricultural and electrical engineering opinion on this new concept of automation in agriculture.

Confronted by many Press and newsreel cameras the tractor emerged from the farm buildings to make its way across the farm-yard, only to find itself faced with a set of traffic lights erected specially to control its passage across a main farm roadway. As the lights were red the tractor stopped short of the roadway, waited for the green signal, and crossed through a gateway into an open field. Next a fertilizer distributor mounted on the rear of the tractor was automatically set in motion, and the tractor travelled round the 500 yd course in the field spreading fertilizer as it went and shutting the distributor mechanism off as it approached the gateway again.

Obeying the traffic signals it returned to the farm shed, reappearing shortly afterwards with another predetermined job to do. This time it was towing a trailer with a moving floor on which were placed five hay bales. The

tractor proceeded to the field as before and during the course of its circuit deposited the hay bales separately at five predetermined points. It then returned to base again.

On a third sortie, towing two trailers on which were arranged a number of straw bales, it came to a halt in the field where the Press and spectators were given an invitation to ride on the trailers, which they readily accepted. During the journey they observed a notice board with the inscription 'All driverless tractors must sound their horns twice on reaching this point', and to their delight this command was obeyed.

The automatically controlled tractor in the field
The traffic lights may be seen in the right background

Safety devices

On the return leg of the journey the three safety devices incorporated in the control system were demonstrated. First one of the demonstrators intentionally stood in the path of the tractor and was struck by the cow-catcher bumper, when the tractor immediately stopped. In the second case the tractor wandered from its predetermined path and again was halted for that reason. In the third instance controlling equipment back in the farm buildings was switched off, and the tractor came to an immediate stop.

To show that the ordinary manual control of the tractor had in no way been interfered with by the installation of automatic control the tractor was driven back to the farm-yard.

The control system

The control of the tractor was achieved by laying an insulated wire beneath the surface of the ground with a light mole plough over the whole length of the circuit traversed. An alternating current of 1 amp, 1 kc/s was made to flow in the wire. On an arm mounted centrally under the tractor and projecting in front of it were carried a pair of sensing coils, and the signals from these were amplified by transistorized equipment and transmitted to a centre-stable relay mounted on the top of the tractor. The signals from the relay were sent to a solenoid-operated valve controlling the hydraulic steering mechanism.

Two further sensing coils were installed one on either side of the tractor just forward of the rear wheels, and these picked up signals at preselected points on either side of the main guide cable. The amplified signals from either of these coils could be connected to a variety of circuits to operate the clutch, hydraulic lift, horn, or mechanisms on mounted or trailed implements. A further sensing coil was mounted centrally between the two steering coils, and this acted as a 'no-signal' relay to stop the tractor in the event of signal failure or any divergence from the predetermined course.

Looking far ahead

There are many occasions in normal farming operations when it is necessary for a tractor or tractors to make numerous journeys over the same route in the course of a day carting silage, manure, potatoes, hay and other materials, and it is not unduly futuristic to suggest that the system demonstrated could if it were commercially available at a reasonable price be used for such work. But those responsible for the project are looking further ahead than this, perhaps ten or 15 years, to the time when the bulk of repetitive farm tasks can be done automatically.

The system demonstrated does not lend itself in its present form to ploughing, cultivating, harvesting, etc.; but it is hoped that the University and the E.R.A. working jointly will be able to carry out the necessary research to perfect the systems that will lend themselves to farm work of the more complex type. Help and encouragement have already been forthcoming from the electrical and agricultural engineering industries.

It may be that such a project is a little premature, but those concerned with it are convinced that automation of this type on the farm is inevitable in years to come and that if this country does not take the initiative it will be taken elsewhere.

To promote the advancement of electrical science

Convention on transistors and associated semiconductor devices on the 21st–27th May 1959

Transistors are now available in over 800 different types and are being manufactured by some 81 companies in about 16 countries. In 1959 world production of transistors will almost certainly be over 100 million.

This extraordinary development since its invention in 1948 places the transistor in the front rank of interest. The Institution's international convention in May 1959 was designed to consolidate past progress and provide a basis for future planning in this field.

The author of this account was responsible for the organizing of information services for the convention.

R. C. WINTON, B.SC., MEMBER

WHEN Lord Hailsham opened the international transistor convention at Earls Court, London, before an audience of 1600 on the 21st May 1959 he set in motion the largest convention ever organized by The Institution and there came to fruition the work of the organizing committee set up by the Electronics and Communications Section under the chairmanship of Dr. R. C. G. Williams.

A phase of consolidation

Our Royal Charter requires us '. . . to promote the general advancement of Electrical Science and Engineering and their applications and to facilitate the exchange of information and ideas . . .' and among other activities for that purpose 'to hold or promote Exhibitions . . .'.

The rapid growth of technical developments especially in the electronics field has caused these objects of The Institution to increase very rapidly in scope and has led to the holding of more and larger conventions year by year. This trend culminated in the transistor convention.

There was good reason why a convention on transistors should be held at this particular time. In the transistor field the initial period of startling new developments has been coming to an end, and we have entered a phase in which the transistor has established its position and can cover the more obvious electronic applications. The main requirement was to consolidate past progress and introduce these new developments into adjacent fields.

The Electronics and Communications Section who conceived the idea for the convention and with the approval of the Council were responsible for organizing it realized that this consolidation could best be achieved by an international meeting of experts from all over the world. Such a meeting would enable the point to which various transistor and semiconductor techniques had advanced to be assessed and would provide a basis on which future developments could be foreseen and planned.

Two new features

From these starting-points a convention was organized of which two features were new to The Institution. First the convention was not held, as most forerunners had been, in the Institution buildings but at Earls Court, and secondly the convention had associated with it a full-scale exhibition of a highly scientific nature and intended to support the proceedings.

The chain of events leading to these results really started when the organizing committee estimated that the number of delegates was likely to be some 2000 (a remarkably accurate shot in the dark, for the number of delegates actually registering was 2051; 399 of these came from abroad and represented 26 countries).

As such large numbers could not be accommodated in the Institution building the committee hit on the happy idea of a combined convention and exhibition in which the professional organizers of the latter in addition to carrying out all the detailed arrangements with the exhibitors provided the necessary meeting accommodation.

Giving it a name

After the convention had been opened by Lord Hailsham introductory lectures were given by the three co-inventors of the transistor, Prof. J. Bardeen, Dr. W. H. Brattain and Dr. W. B. Shockley. It was absorbing to hear scientific history retold by the men who made it and indicative of the speed of

At the beginning

Left to right: Mr. G. Millington, Dr. W. H. Brattain, Prof. J. Bardeen, Dr. W. B. Shockley, Lord Hailsham, and Mr. S. E. Goodall

modern progress that inventors should be honoured for the full significance of their invention during their lifetime.

There were interesting and amusing sidelights from the inventors during the convention too; at one of the convention lunches Dr. Brattain told us how the name 'transistor' had been found, and at the convention dinner at the Connaught Rooms Dr. Shockley, standing on a chair at the top table in front of nearly 400 guests, produced a bouquet out of thin air and ceremoniously handed to it the President.

The momentum of the opening persisted throughout the convention when 129 papers were presented in 23 sessions (11 specialist, 12 general) covering materials, basic theory, characteristics, manufacture and applications. That so much material could be properly dealt with in the time was due almost entirely to the work of the technical programme sub-committee under the chairmanship of Mr. V. J. Francis.

It is not possible to give anything like a comprehensive review of the convention in the space available here; the following is a survey of just a few of the points brought out during the discussions. Those anxious to have a detailed knowledge of the progress recorded cannot do better than apply to The Institution for a copy of the proceedings of the convention which will include reports of all the discussions.

Dr. Shockley presents his bouquet at the convention dinner

Lord Hailsham tries a transistorized hearing aid on the Post Office stand at the exhibition

'Solid circuits'

The versatility of semiconductors was well shown by talk of switching hundreds of amperes and of operation at 3 Gc/s. There was also mention of 'solid circuits' in which circuit-elements are produced on very small wafers of semiconductor material so that the circuit becomes part of the transistor rather than the reverse.

Some of the papers on manufacturing techniques considered the relative merits of alloying, growing and diffusion methods of forming junctions. The grown junction may be somewhat cheaper but restricts the freedom of design; the alloy type while giving greater design freedom is more expensive and less reproducible. The diffused junction appears to hold the greatest future promise, having the widest field of application, but is at present the most difficult and costly of the three to manufacture.

A conflict on reliability

On reliability there was a rather unlooked-for conflict of views.

One estimate indicated no process in transistors which would lead to a definite end of life, whereas another paper gave results showing that a rapid increase in collector–base leakage current had limited life to some 2000 h.

In the applications sessions a number of papers dealt with switching and computing circuits. Pulse rates up to 50 Mc/s are now in development; transistors are particularly suitable for such applications because they make it possible to pack circuit-elements closer together, thus reducing pulse-transmission time. Considerable attention was also given to telecommunication applications for both speech and carrier systems.

A dynamic art

Throughout the convention the attendances remained high, even on the last day. When it was all over no one could reasonably doubt that it had amply justified the planning and hopes of the organizing committee. One fairly widespread criticism nevertheless merits attention—that the convention had covered too much ground.

Dr. R. C. G. Williams with a member of the Institution staff at the exhibition

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As more and more information becomes available in every field of science any attempt to cover an entire subject as this convention covered the whole range of semiconductors is liable to provide more food for thought than delegates can be expected to digest at the time. Whatever the answer to this difficulty—perhaps it means shorter and more specialized conventions—it emphasizes the fact that planning international conventions is now a dynamic and not a static art which must take into account not only the requirements of the subject but also the needs and preferences of the delegates.

An illustration of progress

The exhibition, covering as it did just a single field of technical advance and having a highly scientific content which included many research and development exhibits, was of a new kind.

The primary aim of associating an exhibition with the convention was to place on view exhibits illustrating progress in transistor and semiconductor techniques.

The exhibition was intended to appeal not only to delegates to the convention but to all others with a scientific interest who were not taking part in the convention itself. To this end the exhibition was broadly planned under three headings—semiconductor devices, applications of semiconductors and associated components, and research and development. Stands were taken by 88 exhibitors. Over 33000 people attended including 922 students and scholars in 73 parties spread over the whole period of the exhibition under arrangements made by The Institution.

A focus of interest

Another highlight of the convention was the interest it created in the Press and on the radio. In addition to an oversea broadcast made several months before the opening day and intended to call the attention of potential oversea delegates to the convention there was a talk on it in the 'Science survey' programme of the B.B.C. while the convention was in progress. There was a Press coverage which can only be regarded as most satisfactory for an event of this kind.

In retrospect one can see that far more has been done than just organizing a convention. Not least, thousands of people—from the scholar to the professional engineer—have had the opportunity of hearing and seeing at close hand something of the developments which are leading to a new era in electronics.

INTERNATIONAL CONGRESS ON MICROWAVE VALVES

FURTHER information has been received from the Verband Deutscher Elektrotechniker regarding their international congress on microwave valves at Munich from the 7th to 11th June 1960 which was announced in the May 1959 *Journal*, p. 332.

The subjects for discussion at the congress will be grouped as follows: diodes and grid-controlled valves, velocity-modulation valves, travelling-wave tubes, O- and M-type backward-wave oscillators, magnetrons and M-type amplifiers, cavities and slow-wave structures, space-charge waves, noise, electron guns and beam-focusing, parametric amplifiers and masers, gas-discharge valves, generation of electromagnetic energy by radiation, measuring techniques, and technology.

Intending contributors are asked to submit three copies of a short summary of less than 50 lines for each contribution to this address: Vortragsausschuss der Internationalen Tagung, 'Mikrowellenröhren', z. Hd. Herrn Prof. Dr. W. Kleen, München 8, Balanstrasse 73, by the 30th December 1959. Papers may be read in German, English or French, and the maximum time allocated for the reading of each contribution will be 20 minutes. Summaries of the papers accepted will be printed and made available on or before the opening date of the congress.

COLLOQUIUM ON MACHINE NOISE

THE Société des Ingénieurs Civils de France is organizing in collaboration with the Groupement des Acousticiens de Langue Française, the Société Française des Électriciens and the Société Française des Mécaniciens a colloquium on machine noise which will take place on the 9th–11th December 1959 at the headquarters of the Société des Ingénieurs Civils de France, 19 rue Blanche, Paris 9e.

Any members who wish to take part in this colloquium may register by writing to the Secretariat at 19 rue Blanche. The registration fee which carries with it the right to receive the texts of the communications made is 3000 francs.

High-quality microphones

This article is based on an Electronics and Communications Section paper (2798) with the above title by M. L. Gayford, B.Sc.(Eng.), Associate Member. The paper was published individually in February 1959 and will be republished in Part B of the Proceedings.* *The author is with Standard Telephones and Cables Ltd.*

HIGH-GRADE microphones have many applications nowadays in broadcasting, sound recording, sound reinforcement, noise and reverberation measurements, etc., and the precise nature of their acoustical, mechanical and electrical requirements depends on the particular application. A survey is attempted here of basic operating and design principles for microphones of omnidirectional and directional types.

General principles

High-quality microphones should conform to certain general requirements, although those designed for particular applications may be made to favour certain aspects of the general over-all performance requirements at the expense of others.

As electro-acoustic transducers, microphones should have an adequate efficiency of energy conversion, so that a good signal/noise ratio is obtained at an amplifier input. The electrical impedance should be suitable for use with normal input-cable systems (generally 30, 200, 600 or 10000 ohms). The frequency response, transient response and non-linearity should not, in general, be appreciably worse than those of the amplifier system used.

The directional response of microphones should fall into one of the three recognized categories, namely omnidirectional, bidirectional or unidirectional. There should be a minimum variation of the polar response-curve shape over the audio-frequency band. This is difficult to achieve, owing to wave-interference and diffraction effects which occur because for high frequencies most microphones are comparable in size to the wavelength of sound.

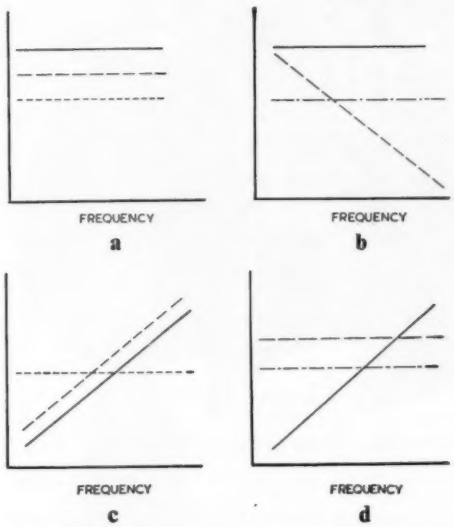
In addition, microphones must not be unduly affected by damp or dirt, must not be too sensitive to vibration, wind or breath noises, and must be reasonably well screened against the effects of stray electrostatic and electromagnetic fields. Microphones used for stage and screen applications may also have to be light in weight and unobtrusive in appearance.

Properties of omnidirectional microphones

Omnidirectional microphones are used where sound has to be collected over a large solid angle without appreciable directional discrimination: for example, where sound is to be picked up from widely dispersed sources, where the maximum ratio of reverberant to direct sound is desired, and for measurements of total noise or of reverberant sound fields.

They are basically pressure-operated devices, responsive to the sound pressure. This is a scalar, i.e. a non-directed, quantity. Thus, an omnidirectional microphone has a construction characterized by a rigid, non-porous, enclosed case, with the diaphragm or other movable part of the transducer exposed to the sound pressure and occupying part of the surface.

The over-all size must be small compared with the wavelength of sound, or the effects of sound-wave diffraction round the case will cause the sound pressure on the diaphragm



1 *Basic acoustic-mechanical operating principles of microphones*

——— Actuating force — — — Mechanical impedance
– – – – Velocity — – – Displacement
Ordinate scales represent the above quantities

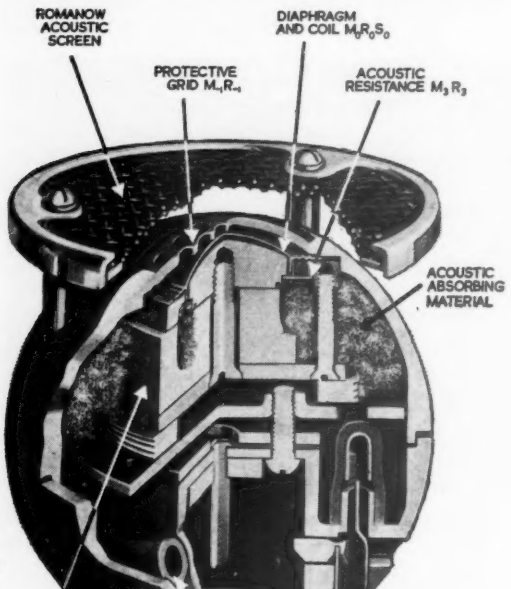
a Pressure-operated system with resistance control, e.g. omnidirectional moving-coil microphone
b Pressure-operated system with stiffness control, e.g. omnidirectional piezo-electric or condenser microphone
c Pressure-gradient-operated system with mass control, e.g. bidirectional or unidirectional ribbon microphone or unidirectional moving-coil microphone
d Pressure-gradient-operated system with resistance control, e.g. unidirectional condenser microphone

For **a** and **c** constant velocity of the conductor in the polarizing magnetic field generates constant e.m.f. at all frequencies
For **b** and **d** constant displacement of the system generates constant e.m.f. at all frequencies

* This article is based on, and written by the author of, a current Institution paper. The author has been asked to make the article so far as possible interesting and of appeal to electrical engineers who have no specialized knowledge of the subject, and the content is not necessarily confined to the subject-matter of the original paper

surface to change with the angle of sound incidence. It is found that, even for the smallest generally practicable sizes of about 0·5in. diameter, there are still diffraction effects of up to 10dB.

An additional effect, called phase loss, occurs at high



2 *An omnidirectional moving-coil microphone*

frequencies for sound incident in a direction other than normal to the plane of the diaphragm. This is because there is an appreciable phase difference in the pressure wave over the distance represented by the diaphragm diameter.

It is thus necessary, even for small microphones, to resort to special means in order to achieve a good omnidirectional response.

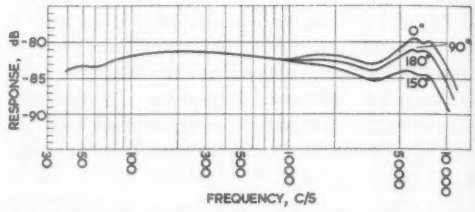
Properties of directional microphones

The operation of directional microphones is based on effects dependent on distance. The pressure-gradient-operated type is responsive to the pressure difference between two separate areas. This is a vector quantity aligned with the direction of sound-wave propagation. Other types depend on reflectors, or on the effects of wave propagation in various structures, in order to obtain directivity. Directional microphones therefore generally have a case in which two or more entries allow sound access to the moving system.

They have particular advantages in broadcasting and sound recording, when it is desired to discriminate against reverberant sound or background noise or to enable a microphone to be used at a greater distance from a sound source or, again, to give a sense of directional sound location, as in some stereophonic sound-recording systems.

Mechanical characteristics

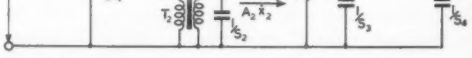
For all microphones, in addition to obtaining the desired polar response, the relationship between the operating principles of the electro-mechanical transducer and the motion imparted to the moving element must be studied, so that a flat frequency response results. To a first order of



3 *Free-field response of the microphone of Fig. 2*
0dB = 1 volt per dyne/cm²

accuracy, the relationships which apply to the three basic types of microphone transducer are shown in Fig. 1, from which the required mechanical-impedance characteristics of the systems are derived.

In Fig. 1a, the governing element in an omnidirectional moving-coil microphone will be an acoustic resistance tightly coupled to the diaphragm system, which should have a relatively low restoring stiffness. The stiffness-controlled omnidirectional system (Fig. 1b) is characterized by the light and relatively tightly stretched diaphragm of the electrostatic (condenser) microphone or by the high stiffness of a crystal slab.



4 *Lumped-constant equivalent circuit for the microphone of Fig. 2*
p = Acoustic pressure on microphone openings
T_1 and T_2 are ideal transformers representing the action of the dome and surround areas of the diaphragm
The other constants of the circuit will be identified from Fig. 2

For a directional microphone of the simple first-order gradient type, such as the ribbon microphone shown in Fig. 1c, the actuating force is approximately proportional to frequency, and the mechanical impedance must be mass controlled. Thus, the ribbon is made very flexible and has its fundamental resonance at the lowest audio frequencies. Fig. 1d shows the conditions for a directional condenser microphone where a resistance-controlled system is given constant displacement by the gradient force.

The design of practical microphones of high performance is necessarily more complicated than indicated by the above basic theory. Examples of microphones at present in use are described later.

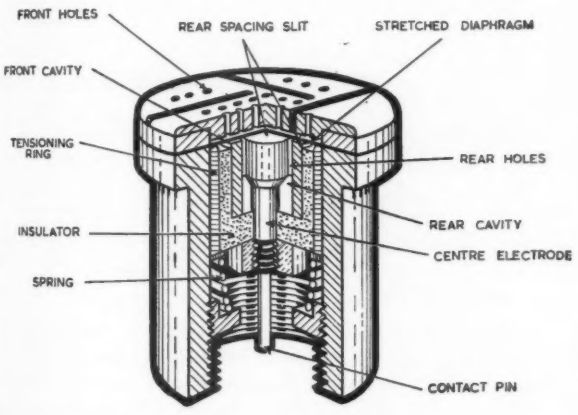
Omnidirectional microphones

Many types of omnidirectional microphone are used, operating on dynamic, piezo-electric or electrostatic principles. They generally have to be greater than about 0·5in. in diameter in order to have a useful efficiency. Various measures have been adopted in order to offset the resulting diffraction effects which upset the high-frequency omnidirectional properties.

Smooth case-shapes of nearly spherical form and other devices, such as the distribution of sound entries at points of minimum diffraction effect, are of some help. However, a semi-reflecting front screen placed in front of the diaphragm openings can nullify diffraction effects to a remarkable extent. It operates by attenuating sound arriving in the 'head on' direction while boosting sound from the rear by reflecting it back onto the diaphragm openings.

Fig. 2 shows a typical omnidirectional moving-coil microphone and Fig. 3 its response curves. The diaphragm is made of aluminium alloy or a suitable plastic and consists of a stiff domed centre carrying a self-supporting speech coil wound from aluminium tape. A front protective grille, a pole-piece and magnet system providing a radial magnetic field across the speech coil, an enclosing case and a leak path from the inside of the case must be provided.

Some cavities, such as the main case volume, will be large enough at high frequencies to give rise to standing-wave effects, which must be damped out by suitably distributed acoustic absorbent. The main case is spherical, as it is well established that diffraction and obstacle effects are less severe for a sphere than for other shapes.



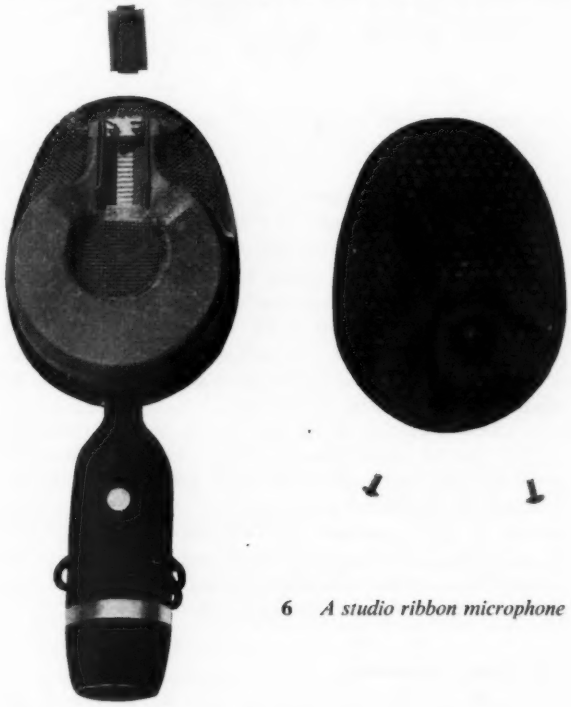
5 *An omnidirectional condenser microphone*

In another similar moving-coil microphone the main case has the form of a tapering cylinder with as small a diameter as possible.

In both cases, a front screen can help to maintain an omnidirectional response. A screen for the tubular microphone has to be larger than the microphone diameter and is often omitted at the expense of the upper-frequency omnidirectional properties in order to make the appearance of the microphone as unobtrusive as possible.

An analogous electrical network for these microphones is shown in Fig. 4, and it is seen that the equations of motion for the acoustic-mechanical system also apply to the equivalent circuit. The areas on the rear side of the diaphragm inside and outside the speech coil are coupled via the pole-gap slots on each side of the speech coil, and this configuration leads to the two transformers in the analogous circuit.

Wave-propagation effects are assumed to be absent, as lumped constants are used for the different elements. With the amount of distributed damping used, the circuit represents a useful approximation to the actual microphone. The front grille openings form a damped Helmholtz resonator with the air cavity in front of the diaphragm and help to maintain the



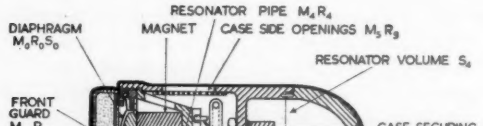
6 *A studio ribbon microphone*

extreme top response. The governing element over the middle-frequency range is the acoustic resistance below the coil slot.

Fig. 5 shows a fairly small omnidirectional condenser microphone, in which the stretched metal diaphragm is tensioned by spring-loading on a rear peripheral ring. The central back electrode structure is insulated from the main case and the aluminium-alloy diaphragm, a polarizing voltage (200 volts) being applied via a high resistance in the conventional manner. Variations of sound pressure vary the capacitance between the diaphragm and back plate, thus producing voltage variations, the charge between the plates remaining substantially constant.

The resonances of the stretched diaphragm are damped by an acoustic network represented by the rear slit between the diaphragm and the back electrode with its perforations and enclosed rear cavity. The smooth response and stability of

such condenser microphones make them useful as calibrated measuring standards. The capacitance is about 40pF, and a head amplifier with a high input impedance and a special low-noise valve is needed.



7 *A unidirectional moving-coil microphone*

Other types of omnidirectional microphone are made in the form of probe-tube devices. The free-field sound pressure acts on the mouth of a tube of fairly small diameter (e.g. $\frac{3}{8}$in.). This experiences only a small amount of high-frequency diffraction on account of its relatively small size. A wave is propagated down the tube (1–3ft long) and is applied to a moving-coil or condenser microphone diaphragm by means of a suitably proportioned coupling cavity, which can be regarded as an acoustic transformer.

In one design, the diaphragm has an acoustic resistance tightly coupled to its rear surface, the transforming cavity being arranged to terminate the probe tube with the correct characteristic resistance, so as largely to avoid standing-wave effects. A small resonant horn coupler at the tube input compensates for the high-frequency losses which occur in the system. Many other probe microphones have been designed for the purpose of particular types of measurement.

Directional microphones

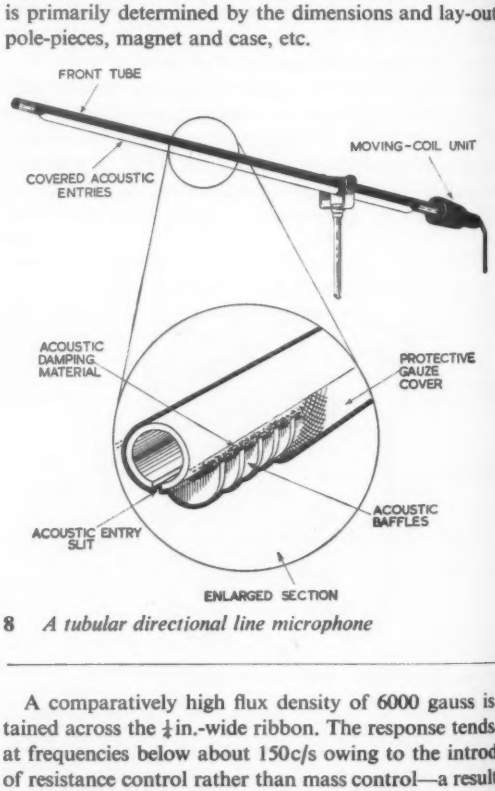
Possibly the best-known directional microphone is the normal ribbon type, which is a bidirectional first-order pressure-gradient-operated device. This is characterized by equal front and rear responses, there being no response to sound arriving in a plane at right angles to these directions. The actuating force is proportional to a pressure-gradient vector represented by the instantaneous pressure difference between the two sides of the ribbon.

The characteristics of the microphone are due to the fact that sound incident from the front and rear directions respectively produces vectors with no change in magnitude but a 180° phase shift, sound incident at 90° producing a vector having no component in the directions in which the ribbon is free to move.

A later development in gradient-operated microphones has been to interpose an acoustic phase-shifting network between the rear of the diaphragm or ribbon and the sound field, giving a unidirectional response of the cardioid type, which has certain advantages over the earlier bidirectional 'figure of eight' response. The frontal solid angle of sound pick-up is increased, while extraneous noises from the rear are suppressed. This helps to reduce audience noise in stage shows.

Highly directional microphones of the unidirectional type have been produced by making use of the effects of wave propagation in long tubes. In contradistinction to the gradient types, whose correct operation depends on their size being small compared with the wavelength, the 'wave' types require to be large compared with the wavelength of sound and thus are liable to lose their full directional properties at low frequencies unless they are made rather large.

Fig. 6 shows a high-quality bidirectional ribbon microphone of fairly recent design. The ribbon is made as short as possible in the vertical direction so as to preserve the high-frequency polar response, the width of the ribbon being as large as possible in order to achieve a high efficiency. It is a strip of pure aluminium leaf and is corrugated along its length in order to increase flexibility and to prevent any tendency for the edges to curl. The motion of the ribbon is substantially aperiodic, and the response of the microphone is primarily determined by the dimensions and lay-out of the pole-pieces, magnet and case, etc.



8 *A tubular directional line microphone*

A comparatively high flux density of 6000 gauss is maintained across the $\frac{1}{4}$in.-wide ribbon. The response tends to fall at frequencies below about 150c/s owing to the introduction of resistance control rather than mass control—a result of the critical damping of the natural resonances of the ribbon. A porous gauze baffle with fairly low acoustic resistance is fitted round the pole-pieces and magnet in order to compensate for this loss.

The total harmonic distortion of this microphone is less than 0·1% for the vast majority of frequencies and sound levels normally encountered in operation. The wiring of the

ribbon is so disposed as to neutralize electromagnetic hum pick-up, and the toroidally wound transformer in the stem is fitted with a Permalloy C shield.

Fig. 7 shows the construction of a moving-coil first-order gradient unidirectional microphone. Acoustic phase-shifting elements couple the rear side of the diaphragm to the outside air.

The main rear opening holes must be substantially resistive and must feed a cavity behind the diaphragm whose value in relation to the resistance of the openings is determined by the external path distance and the particular polar curve desired.

The other requirement is that the moving system of this microphone must be substantially mass-controlled if the gradient force, which rises with frequency, is to give it a flat frequency response.

Both these requirements are difficult to meet over a wide frequency range, and special means have to be adopted to get the desired results at both extremes of the frequency scale. It is arranged that the unit shall change gradually to a pressure-operated resistance-controlled device at high frequencies, the unidirectional response being obtained by diffraction effects from the casing.

Ribbon, crystal and condenser units have also been designed to function as 'phase shift' unidirectional microphones.

Fig. 8 shows an example of a highly directional tubular 'line' microphone, which achieves a directional characteristic by means of a number of acoustically damped entries in the form of a line slit along a single tube of length 40 or 80 in., the length being chosen according to the degree of directivity required and the discrimination desired at low frequencies. One end of the tube is coupled to the diaphragm of a moving-coil microphone unit.

The coupling of a tube of this sort to a diaphragm via a coupling cavity results in a high-frequency loss, which in this case is offset by the addition of a series of small interconnected baffles mounted between the entries at 90° to the axis of the tube. These baffles give a resonant-cavity gain at high frequencies.

Conclusion

Present-day practice in the design of high-quality microphones has been outlined, and typical examples have been examined.

However, many additional specialized types, such as noise-reducing microphones, as well as a number of subsidiary fittings (e.g. windshields, anti-vibration mountings, etc.), are being developed and improved by various organizations. 621.395.61

H.F. multidirectional aerial

A synopsis of an Electronics and Communications Section paper (3078) entitled 'A multiple-direction universally-steerable aerial system for h.f. operation' by D. W. Morris, B.Sc.(Eng.), and G. Mitchell, B.Sc.(Eng.), Associate Members. The paper will be published in Part B of the Proceedings. The authors are at the Post Office Research Station.

THE authors present briefly the principles underlying the current development of a high-frequency directional aerial system which can be steered in both azimuth and elevation. It comprises a number of omnidirectional unit aerials whose outputs (in the case of reception) may be brought approximately into phase with each other for any desired combination of frequency and direction by means of direction-control equipment which is basically a high-speed computer. The aerial system provides a number of independent outlets each of which may be individually steered by the direction-control equipment. An experimental equipment based on these principles and designed for the reception of h.f. signals from transmitters at long distances will be described in a later paper.

In the present the authors mention some of the potential advantages of this type of aerial system, e.g. flexibility of design and operation, and note that the basic principles are applicable to both transmission and reception. 621.396.677.029 : 58

Synopses of papers

THE following are synopses of papers published in the *Proceedings* which have not been read at Institution meetings and which have not been reviewed in the *Journal*. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints will be available in due course

Sliding-rotor induction motor

A synopsis of a Utilization Section paper (3016) with the above title by D. Midgley, B.Sc., Ph.D. The paper is published this month in Part A of the Proceedings. The author is Lecturer in Electrical Engineering, Queen's College, Dundee, University of St. Andrews.

THE author describes a method of designing an induction motor to have continuously variable speed. It involves a short sliding rotor and a long stator the poles of which are changed gradually over the length. Tests on an experimental model are reported, and the consequences of discontinuities in the stator flux pattern are considered. 621.313.333.2

CORRESPONDENCE

EFFECT OF HUMIDITY ON THE DRY FLASHOVER VOLTAGE OF AIR-GAPS AND INSULATORS

THE corrections for humidity which are to be applied to the measured flashover voltage for insulators are given in generally similar forms in B.S. 137: 1941 (porcelain and toughened-glass insulators for overhead power lines), I.E.C. publication 75: 1955 (specification for porcelain insulators for overhead lines) and American Standard C. 29.1: 1944 (insulator tests). These corrections are all based on the assumption that at power frequency (with which alone this letter is concerned) the flashover voltage increases almost linearly with the humidity of the air, rising by 8–12% for an increase in moisture content from 4 to 11 g/m^3. All three specifications also give warnings that the corrections may be inaccurate.

As far as is known the humidity correction factor has not been measured accurately above 500 kV r.m.s., but in recent years it has been necessary to apply it to considerably higher test voltages and it was in the course of industrial tests in the region of 700 kV r.m.s. that we began to doubt its validity.

Accordingly we have for the last year been measuring the flashover voltage of a variety of air-gaps and recording the humidity at the time of the tests. Enough data have now been obtained to warrant some tentative conclusions, and as it is known that there are national and international technical committees engaged in work for which information on the humidity correction factor would perhaps be of interest and immediate use a brief summary of the results is given below.

Method of test

All the tests were made at 50 c/s inside the laboratory without artificial drying or humidifying of the air: the moisture content varied between 4 and 12 g/m^3, and most of the values were between 5 and 9 g/m^3. The results were adjusted for air density to the standard conditions, namely 760 mm Hg, 20°C

The test objects were:

1. a 100 cm sphere-gap set to break down over distances of 15 and 50 cm (i.e. at 270 and 700 kV r.m.s.)
2. 48, 72 and 96 in. rod-gaps which flashed over at about 450, 660 and 820 kV r.m.s. respectively
3. a large porcelain weather casing with a string flashover distance of 90 in. and a flashover voltage of 650 kV r.m.s.
4. strings of insulators flashing over at up to 900 kV r.m.s.

Results

100 cm sphere-gap

Ten tests were made on each occasion, and the means of the ten values were plotted as a function of the absolute humidity. These mean values had a total spread of less than 4%, and most of them had a spread of less than 2% of the mean. There was no observable tendency for the mean flashover voltage to change as the humidity increased, but there was rather more scatter at the higher humidities. If the humidity over the above range has any effect on the flashover voltage it cannot exceed ±1% at most; hence the change is less than 0·1%/g/m^3.

Greater changes (always in the direction of increased flashover voltage with increasing humidity) have been quoted by many investigators, but their tests were made on small gaps.

For practical purposes at large spacings there seems no reason to doubt either the statement in B.S. 358 that the breakdown voltage of the sphere-gap is independent of the humidity of the atmosphere or the similar statement in the corresponding A.I.E.E. Standard No. 4 (C. 68.1: 1953) that humidity has a negligible effect.

48, 72, and 96 in. rod-gaps

On a 48 in. rod-gap the effect of humidity appeared to be slightly higher than B.S. 137 would suggest, but the practical difference is small and about the same as the scatter of the results. On 72 and 96 in. rod-gaps measurements have so far been made only at humidities from 8 to 12 g/m^3, and over this range the effect was slight, if indeed humidity had any effect at all.

Large porcelain weather casing

The evidence here is not definite, but it appeared that there was a slight upward trend of flashover voltage with humidity up to 7 g/m^3; thereafter the results became very erratic and seemed in fact to be decreasing in value. All that can safely be said at this stage is that up to 7 g/m^3 the flashover voltage rises rather less than would be expected from B.S. 137 and at higher humidities the flashover voltage appears to be either independent of humidity or falling slightly.

Strings of string-insulator units

At up to about 500 kV r.m.s. the effect of humidity is rather less than is implied in B.S. 137. Longer strings show the same tendency as the large porcelain weather casing. The tendency for the flashover-voltage/humidity curve to bend over becomes perceptible at about 500 kV and becomes more and more obvious as the voltage increases. When the humidity increases beyond 7 g/m^3 the curve ceases to rise if the flashover voltage is about 600 kV r.m.s. and tends to fall at higher flashover voltages.

It is interesting to note that the rod-gap shows the same tendency to a smaller extent.

In conclusion we wish to emphasize these limitations of our test results:

1. Tests were made at power frequency only
2. Only one make of porcelain insulator and one make of string insulator were tested. We cannot say therefore whether all makes would behave similarly
3. At any time of the year the natural humidity of the air of the laboratory varied over only a part of the total range of 4–12 g/m^3 mentioned above, and consequently it is only in

tests which have been in progress for many months that an adequate number of points over the whole range have been obtained.

4. The results showed considerable scatter, especially in the region of high humidity.

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24th August 1959

SPACE-CHARGE-LIMITED DIELECTRIC DIODES

AT the international convention on transistors in May 1959 some experimental cadmium sulphide 'dielectric diodes' were demonstrated and their basic theory and characteristics described.[1] These devices exploit the properties of space-charge-limited (s.c.l.) current in insulators and should complement semiconductor devices particularly in applications where insensitivity to temperature changes or where operation at high frequencies is required. The purpose of this letter is to describe briefly some further measurements which have been made of the temperature-dependence of current and of the fast-pulse response.

For these measurements diodes were selected which possessed a small or zero 'traps-filled voltage threshold' for forward current. Such diodes are effectively free from deep electron traps and possess the square-law dependence of current on applied voltage expected for s.c.l. current in insulators.[2]

The steady forward characteristics of several such diodes were measured in the dark over the temperature range $-190°$ to $+120°$C. In all cases the temperature-dependence of current was slight. This was as expected since in s.c.l. conditions the number of electrons available for current flow is independent of temperature. In a typical case with 9 volts applied the current increased from 8 mA at 120°C to 12 mA at $-190°$C. The increase in current as the temperature fell is attributed to the rise in mobility of the electrons although this effect is opposed by increased trapping of electrons in shallow traps at the lower temperatures.

The current response of the diodes was expected to be extremely rapid for 'switch-on' and 'switch-off' operation. Anticipated response times are of the order of the electron transit time and should be in the range 10^{-11} to 10^{-8} sec depending on crystal thickness and applied voltage. The current response of two typical diodes was examined, again in the dark, using voltage pulses with a rise time of the order of 1 millimicrosec and a sampling oscilloscope with a response time of about 3 millimicrosec; no detectable difference could be observed between the rise of the applied voltage pulse and the current response of the diodes.

The 'switch-off' characteristics were examined by applying a steady positive voltage to give a forward current of about 10 mA and turning this voltage negative in a time of the order of 1 millimicrosec. Again the response time of the diodes was less that than of the measuring equipment. Further an integration of the reverse current using equipment designed to measure hole-storage effects in semiconductor diodes showed that there was no detectable mechanism analogous to hole-storage in semiconductors.

Measurements of the sort described here have so far been made on only a small number of diodes. In all cases however the results have been in accord with theoretical anticipation, and there seems no reason to doubt that they will prove characteristic of these devices in general.

Even in its present experimental form therefore the cadmium sulphide dielectric diode indicates the potential value to electrical engineering of the new solid-state devices which are being developed by exploiting the properties of s.c.l. current in insulators. Further as a research tool in basic physics the mechanisms of current flow in insulators offer new techniques for studying the electronic structure of and lattice defects and carrier mobilities in dielectric crystals.

We would like to thank Prof. D. G. Tucker of the Department of Electrical Engineering for the provision of facilities for this research. Thanks are also due to the Department of Electron Physics for the loan of the apparatus which made the low-temperature measurements possible and to the Electronics Division of the United Kingdom Atomic Energy Research Establishment, Harwell, for making the measurements of pulse response and charge storage described.

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G. T. WRIGHT, B.SC., PH.D., A.INST.P., GRADUATE I.E.E.

Materials Group
Department of Electrical Engineering
University of Birmingham

4th September 1959

1. WRIGHT, G. T.: 'Some properties and applications of space-charge-limited currents in insulating crystals', *Proceedings I.E.E.*, Paper No. 2928, May 1959 (**106B**, Suppl. 17)
2. WRIGHT, G. T.: 'Space-charge-limited currents in insulating materials', *Nature*, 1958, **182**, p. 1296

WHAT IS NEGATIVE IMPEDANCE?

WE can claim like Humpty Dumpty that when we use a word it means what we choose it to mean. We cannot however derive meaning from a self-contradictory expression like 'square triangle'. Is the expression 'negative impedance' likewise self-contradictory? This is a simple, elementary question and therefore difficult to answer although nearly everyone attempts an immediate answer.

Here we seek the help of the Fourier integral which is based on very accurate and careful thinking and has been amply verified.

We must avoid the error of taking premature limits. Following the example of engineers and working mathematicians (rather than teachers) we therefore take the impedance of a unit pure inductance as:

$$Z_1 = \lim_{\alpha \to +0} (p + \alpha) \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and the impedance of a unit pure resistance as:

$$Z_2 = \lim_{\nu \to +0} (1 + \nu p) \quad . \quad . \quad . \quad . \quad (2)$$

where α, ν represent residual impurities and can be regarded as real numbers which are as small as we please but normally essentially positive.

By means of the Fourier integral we find that the current resulting from the application of unit impulse to the impedance Z_1 is:

$$h_1(t) = \lim_{\alpha \to +0} \frac{1}{2\pi j} \int_{-j\infty}^{j\infty} \epsilon^{zt} \frac{dz}{z+\alpha} = \lim_{\alpha \to +0} H(t) \exp(-\alpha t) \quad . \quad (3)$$

where $H(t)$ is the Heaviside unit step, so that $h_1(t)$ is zero for $t < 0$.

If however α is negative, say $-\beta$, the impedance of our unit inductance becomes:

$$Z_3 = p - \beta \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and the Fourier integral gives the corresponding current as:

$$h_3(t) = -H(-t) \exp(\beta t) \quad . \quad . \quad . \quad (5)$$

which is different from zero only for negative values of t. But if α is made zero *ab initio* in eqn. (1) the impedance reduces to p and the current $h_4(t)$ to:

$$h_4(t) = \tfrac{1}{2} \operatorname{sgn} t \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

This solution represents a possible but infinitely improbable state of affairs which 'takes no room in logical space'.

If in eqn. (5) we replace t by $-\tau$ eqn. (5) reduces to eqn. (3) with β for α and τ for t. Eqn. (5) thus belongs to a world in which the flow of time is in the opposite direction to that in our world though still in a direction associated with increasing entropy.

The important question however is surprisingly simple: is a particular entity adequately specified? Eqn. (3) is an adequate specification in terms of the specified network and the specified unit-impulse interference therewith. The impedance Z_3 however is 'explosive', and the specification requires a statement of the amount of explosive material or of the value of current or voltage at which fuses will blow or other non-linearities terminate the explosion.

The Fourier integral is incapable of giving a dummy specification like:

$$h_5(t) = H(t) \exp(\beta t) \quad . \quad . \quad . \quad (7)$$

but if we know the amount of explosive material or the conditions terminating the explosion, so that we can deduce the time of termination as t_0, we can complete the specification as:

$$h_5(t) = \exp(\beta t)\,[H(t) - H(t - t_0)] \quad . \quad . \quad (8)$$

This however is not the solution for a network existing prior to zero time and then excited by an impulse but for a network created in a state of quiescence at zero time and then given an impulse. The Fourier solution for a network which ceased to behave as the impedance specified by eqn. (4) at time t_0 is simply:

$$h_6(t) = -H(t_0 - t) \exp(\beta t) \quad . \quad . \quad . \quad (9)$$

Thus the term 'negative impedance' is open to the same kind of criticism as eqn. (7); neither represents a complete specification and neither allows a state of affairs to be deduced. The appearance of a pole with a positive real part in an impedance function indicates the presence of a servo-controlled source of energy which must be adequately specified, for example in terms of the total energy it can contribute.

We are concerned here with logic and semantics; the question at issue is not about the properties of the physical world; we have to decide whether the particular phrase 'negative impedance' is a usable specification or not.

W. PROCTOR WILSON, C.B.E., B.SC.(ENG.), MEMBER
C. G. MAYO, M.SC., MEMBER
J. W. HEAD, M.A.
B.B.C. Research Department
Kingswood Warren
Tadworth, Surrey

8th September 1959

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

JOHN CAREY-BROWN

John Carey-Brown, B.SC., who died in Calcutta on the 21st July 1959 was born in Montrose, Scotland, on the 9th October 1903. He was educated at Montrose Academy and at St. Andrews University where he obtained a B.Sc. degree in electrical and mechanical engineering. He received practical experience with the British Thomson-Houston Co. at Rugby, Birmingham and Willesden.

He went to India in 1929 and became manager of the Bombay office of the then B.T.H. Co. (India). Subsequently when Associated Electrical Industries (India) Ltd. was formed he became manager of the Lahore office of that company and later manager of their Bombay office. He was also appointed a director. He retired from Bombay in 1958 but returned to India in January 1959 to take up the position of sales director of the company in Calcutta.

He was a man of quiet disposition and had a wide variety of interests. He was a keen sportsman, interested in horse riding and in water polo in which he participated in Bombay. He was a member of the Kirk of Scotland. His wife predeceased him by 13 months, and this loss affected him greatly. He is survived by two daughters aged 17 and 13.

He joined The Institution as a Student in 1927 and was elected a Graduate in 1929, an Associate Member in 1933 and a Member in 1945. He served on the Bombay Local Committee from 1941 to 1948, from 1950 to 1953 and from 1954 to 1956. J. H. S.

WILLIAM ANTHONY AMBROSE BURGESS

William Anthony Ambrose Burgess who was born at Magdalen, Norfolk, on the 19th September 1887 died at Hellisden Hospital, near March, on the 22nd May 1959 after a short illness. He was educated at King Edward VII School, King's Lynn, and part-time at King's Lynn Technical College and at Durham University. He received practical training with the King's Lynn municipal electric supply undertaking as an articled apprentice and with the Newcastle-upon-Tyne Electric Supply Co.

In 1907 he joined Merz and McLellan, Newcastle, as an electrical draughtsman and became an assistant electrical engineer in 1913. In 1916 he joined British Dyestuffs Ltd., Huddersfield, and was appointed chief electrical works engineer in 1918. He was responsible for the works installation and put into service the power station and feeder plant at Dalton and Tunbridge works.

In 1924 he became a member of the staff of A. Reyrolle and Co. and in that year the Midland area manager. He held this position until forced to retire in 1949 owing to ill health. He supervised automatic substation contracts in the early thirties and later became contracts engineer responsible for the company's contracts with the Central Electricity Board, operating for most of this time from headquarters at Hebburn.

He was a man with wide experience and technical knowledge which he applied to the diverse problems associated with electrical switchgear and one who always enjoyed tackling new projects and accepted responsibilities without fear or favour. His independent spirit and forthrightness were blended with a quiet sense of kindly humour. These characteristics endeared him to his staff who were always conscious of his interest in their welfare.

He was essentially a countryman, coming from farming stock, a garden-lover and later a keen fisherman. His wife died in 1936: a loss from which he never really recovered as he was a great home-lover and family man. He was one of the founder members of the Cambodunum Lodge at Huddersfield formed in 1919 and was worshipful master in 1923. He is survived by his two daughters and a son.

He joined The Institution as a Student in 1908 and was elected an Associate Member in 1912 and a Member in 1919. He served on the North-Eastern Centre Committee from 1935 to 1938 and was vice-chairman from 1938 to 1940 and chairman in 1940–41. His chairman's address entitled 'The industry's present and possible part in the national struggle' was published in the *Journal* in 1941.

A. J. C.

BOYD DAWSON

Boyd Dawson who died suddenly in Bromsgrove General Hospital on the 6th September 1959 was born on the 19th August 1876. He was educated at Bedford Modern School and attended evening classes at Barrow Technical School and at Chelsea Polytechnic while apprenticed to the Naval Construction and Armament Co. which later became Vickers, Sons and Maxim during his time.

In 1900 he joined Chelsea Electricity Supply Co. as assistant power-station engineer and draughtsman. Three years later he became assistant engineer to O'Gorman and Cozens-Hardy, consulting engineers in Westminster. He was engaged in the design, specification and supervision of erection and testing of factory power projects and schemes for works lighting, heating and water. In 1908 the partnership changed to Swinburne, O'Gorman and Baillie and in 1910 to Baillie and Dobrée. He was then appointed chief assistant and was in sole charge in the absence of the partners on war service. He described this as the 'happiest time of my life'.

In 1924 on the dissolution of the partnership he went into business on his own account as a consulting engineer. At the beginning of the Second World War he was engaged on confidential work for the Ministry of War and in 1942 became chief engineer with Macrome Ltd., Wolverhampton, dealing with the design and lay-out of two new factories. He retired in 1947.

His wife predeceased him.

He joined The Institution as an Associate Member in 1905 and was elected a Member in 1924.

ANDREW SIMPSON GRAY

Andrew Simpson Gray who was born at Dalkeith near Edinburgh on the 31st December 1872 died on the 23rd April 1959. He was educated at Royal High School and at Heriot-Watt College, Edinburgh.

In 1892 he was apprenticed to King and Co., Leith electric works, where he spent his whole business life. In 1917 he was appointed works manager and subsequently in 1921 was taken into partnership. He remained in active business as senior partner until a few months before his death, when he disposed of Leith electric works to Leith Nautical College who are now using the premises as an extension of the college.

He was one of the earliest pioneers in Edinburgh of wireless telegraphy and was for many years a lecturer at Leith Nautical College on this subject. In business he specialized in ship and country-house lighting installations and during both world wars was engaged on Admiralty work. One of his electric generating sets dating from the early part of the century is (or was until recently) still functioning in Northern Ireland.

The youngest of five brothers, he remained a confirmed bachelor. He was a veteran motorist, at one time having a car which was propelled by a steam engine and was later converted to petrol. He came of a God-fearing and musical family. He was a founder and conductor of the Dalkeith boys' fife and drum 'Band of hope', later to become the Dalkeith P.S.A. Orchestra under his baton. He was organist in the Dalkeith Congregational Church, was a committee member of the local musical union and was active in amateur theatrical circles, for several years being secretary of the Gilbert and Sullivan Society of Edinburgh. Golf at one time attracted his attention, and he was probably one of the earliest 'train spotters' with an encyclopaedic knowledge of railway working. Gardening and crossword puzzles were his only other hobbies.

He joined The Institution as an Associate in 1903 and was elected an Associate Member in 1912 and a Member in 1945. He served on the Glasgow Local Section Committee from 1902 to 1905.

J. S.

REGINALD CHARLES INSTRALL

Col. Reginald Charles Instrall, O.B.E., B.A., who was born on the 12th August 1897 died on the 15th October 1958. He received his early education at Portsmouth Secondary School and H.M. Dockyard Technical College, Portsmouth. He entered the Royal Military Academy, Woolwich, in 1916 and was first commissioned in 1917 with the Royal Garrison Artillery. He served in Italy and Egypt with the Royal Artillery in the First World War and after his return to this country was seconded to the Royal Corps of Signals.

In 1925 he went to Cambridge University, obtaining a B.A. degree in the mechanical sciences tripos two years later. Subsequently he joined the signal training centre at Catterick as officer-in-charge, Radio Wing. He served in Palestine for five years, returning to Catterick in 1933.

He was transferred to the Ministry of Supply when it was formed and assisted in developing the Signal Equipment Wing, being appointed an assistant director in 1940 and promoted to the rank of lieutenant-colonel, engineer services (2). Four years later he was made deputy director, line equipment, with the acting rank of colonel. During this time he was largely responsible for the supply of the whole of the Army's requirements in radio and line equipment. He later became responsible for the allocation of raw materials for cable-making purposes and was appointed an Officer of the Order of the British Empire in 1948 for his services.

When in 1950 he was retired from the Service and transferred to the Royal Army Reserve of Officers his wide knowledge and experience became available to the Cable Makers Association with whom he remained as testing officer until his death.

He was an unassuming man and a good mathematician and linguist, especially remembered for his longsightedness, his grasp of fundamentals and his flair for extracting the essentials of a complex subject. He was married twice and is survived by his widow, two daughters and two sons.

He joined The Institution as an Associate Member in 1928 and was elected a Member in 1950.

W. H. L. L.

ERNEST LUDVIG REENBERG JEPHCOTT

Ernest Ludvig Reenberg Jephcott who died on the 8th August 1959 was born on the 5th January 1906. He was educated at Milton High School, Bulawayo, and the Boys' High School, Salisbury. In 1923 he entered the Southern Rhodesia Posts and Telegraphs Department as an apprentice. In 1926, prior to the installation of the first automatic exchange at Salisbury, he attended a course of instruction by Standard Telephones and Cables who were then installing an automatic exchange in Durban. Subsequently he directed the installation of many of the earlier automatic exchanges in Southern Rhodesia.

In 1930–31 he attended Marconi College, Chelmsford, where he completed a course in wireless telegraphy. On his return to Southern Rhodesia he installed and commissioned wireless stations at Salisbury and Bulawayo for the use of the Imperial Airways services. Early in 1932 he obtained authority to use these wireless stations for experiments in broadcasting and thus pioneered the post office broadcasting service which continued for 24 years. He was appointed chief engineer of the Southern Rhodesia Post Office in 1946, and in 1954 on the formation of the Federation of Rhodesia and Nyasaland he became the first chief engineer of the Federal Ministry of

Posts which position he held until his premature retirement due to ill health in 1958.

In the early part of his career he was a keen radio amateur and held the first amateur call sign allocated in Southern Rhodesia. He founded the Rhodesian Orchid Society and was president at the time of his death. He is survived by his widow and a son.

He joined The Institution as an Associate Member in 1936 and was elected a Member in 1953. A. M.

SIR WILLIAM JAMES LARKE

Sir William James Larke, K.B.E., D.SC., who died on the 29th April 1959 was born at Ladywell, Kent, on the 26th April 1875. He was educated at Colfe's School and at Regent Street Polytechnic and was apprenticed to H. F. Joel and Co.

In 1895 he joined Siemens Brothers and was in charge of their calibrating and instrument-testing department. Three years later he was engaged as second-in-charge of the power and mining department of the British Thomson-Houston Co., Rugby, and became manager of the department the following year. He left the company in 1915, having reached the position of executive engineer in 1912, to join the Ministry of Munitions. In 1922 he was appointed director of the British Iron and Steel Federation in which position he served for 24 years.

He was chairman of the Iron and Steel Industrial Research Council and in this capacity did much to develop and encourage co-operative research in the iron and steel industry, thus laying a firm foundation for the more extensive work of the British Iron and Steel Research Association which took over from the Research Council in 1945.

He did much to promote the recognition of welding as a specialized branch of technology and took a large part in the formation of the Institute of Welding and later became the first president of the British Welding Research Association.

Sir William combined great firmness and strength of character with an essential kindliness and inspired affection and respect in his staff. His personality was characterized by a deep religious faith and even in his later years by his lively interest in all aspects of the world around him and not least in the activities and well-being of the younger generation. His wife predeceased him earlier this year, and he is survived by a son and a daughter.

He joined The Institution as an Associate in 1897 and was elected a Member in 1906. He served on the Birmingham Local Section Committee from 1910 to 1913. He was appointed an Officer of the Order of the British Empire in 1917, a Commander of the Order in 1920 and a Knight Commander of the Order in 1921.

He served as president of the Institute of Fuel, the British Standards Institution, the Junior Institution of Engineers, and the Institute of Engineers-in-Charge. He was an honorary member and vice-president of the Iron and Steel Institute and received the Institute's highest award, the Bessemer Gold Medal, in 1947. He was a member of the Institution of Mechanical Engineers and an honorary doctor of sciences of the University of Durham and was awarded the Fox Gold Medal by the Institute of British Foundrymen in 1953.

HENRY GEORGE SERAFTON PECK

Henry George Serafton Peck, B.SC.(ENG.), who died on the 25th June 1959 was born on the 26th November 1885. He was educated at Baldock College School.

He joined the National Telephone Co. in 1900 as a youth, studying at West Ham Technical Institute, Northampton Polytechnic and at Finsbury Technical College in the evenings, and was employed on telephone-exchange construction and subscribers' apparatus fitting and maintenance. When the company was transferred to the Post Office he entered that organization as a chief inspector. He entered for the competition limited to serving officers in the Post Office, was successful in the 1913 examination and was appointed assistant engineer in 1914. He then studied in his spare time for the B.Sc.(Eng.) degree of London University and was surprised to find himself among the first-class honours.

After serving in the Royal Air Force during the First World War he returned to the London district of the Post Office and was then transferred to the telephone section of the engineer-in-chief's office where he was concerned with the design and installation of large p.b.x.'s, the wiring of buildings and the conversion of the London and Birmingham areas from manual to automatic working.

On promotion to section engineer he was placed in charge of the London technical section. In 1935 he was appointed assistant superintending engineer in the North Wales district. He returned to headquarters as staff engineer in charge of the equipment branch and made notable contributions to the work done by the Post Office towards the war effort. He served as chief air raid precautions officer in the engineering department and after the war was transferred to the organization and efficiency branch. He did valuable work as chairman of the Telecommunications Panel on the Codes of Practice Committee for Electrical Engineering which he carried on after his retirement in 1949 until his death.

He joined The Institution as an Associate Member in 1911 and was elected a Member in 1921. He served on the South Midland Centre Committee from 1936 to 1939. H. F.

WILFRED BERTRAM THORPE

Wilfred Bertram Thorpe who was born on the 12th August 1875 died on the 27th August 1958. He was educated at Merchant Taylors' School and at King's College, London, with practical training at Vauxhall Ironworks Co. and at Cromptons Ltd.

In 1896 he joined the Charing Cross, West End and City Electricity Supply Co. as assistant engineer. The company had a station at Lambeth which generated at 1000 direct volts. He was concerned with the supervision of the laying of the 1000-volt cables by Callenders on behalf of the company and later had much to do with a special low-voltage theatre main network which provided a duplicate supply to all the theatres and music-halls in the area.

The company succeeded in obtaining powers of supply in the City of London which was already being supplied by the City Co., and Thorpe was concerned with the laying of the 10000-volt mains from Bow generating station to the City. In 1920 he became chief engineer of the company and was especially concerned with the installation of more-modern oil-engined generating plant in Shorts Gardens and St. Martin's Lane, London, and this plant was used to give the alternative supplies to the theatres and for peak cutting.

The company was one of the six London companies which merged to form London Associated Electricity Undertakings, later called Central London Electricity Ltd., and soon after the formation of this undertaking in 1936 he retired but continued to act in an advisory capacity until the end of 1941.

In his early days he was a keen golfer and throughout his life a fishing enthusiast. He was an old Cromptonian, and freemasonry played a most important part in his life. He was considerate and kind in all matters and a very good companion. He is survived by his widow.

He joined The Institution as an Associate Member in 1905 and was elected a Member in 1920. L. H. W.

JAMES LAING WILSON

James Laing Wilson who was born in Kirkcaldy in 1880 died at Eastbourne on the 19th August 1959. He was educated at Perth Academy, at St. Andrews University and at City and Guilds College where he obtained a diploma in electrical engineering. He was apprenticed to J. Carmichael and Co.

After a few short-term jobs he joined Callender's Cable and Construction Co. in 1905 as an assistant engineer. He spent practically the whole of his career in the company's service, working first in South Wales installing e.h.v. cables and overhead lines and then in Calcutta for two years on various cable contracts until his health gave way and James Callender arranged for his six months' recuperation in Switzerland. He returned to South Wales as resident engineer and district manager in 1910.

He was commissioned in the Sappers and served in Gallipoli, Egypt and Mesopotamia in the 1914–18 War. On demobilization he joined the Military Works Department at Baluchistan, India, and was in charge of water and electricity. In 1921 he went back to the Callender fold as resident engineer in Burma, never again to leave the company until he retired in 1945.

His work abroad filled some of his less-favoured colleagues with much envy but no malice for he worked and travelled in all sorts of out-of-the-way corners of the earth, dealing with overhead lines and cabling for the Burmah Oil Co. at Yenangyaung and Singu and electrification of the Anglo-Persian oilfields and of the Abadan refinery, Bahrain, Aden, Wad Medani in the Sudan, Siam where he laid submarine cables, and other places in the Middle and Far East.

He collected most absorbing news of things being done, of people encountered and customs seen. 'Why on earth didn't you *write* about all this sometimes?' one would ask. 'Och! I was busy and knew it would keep until I saw you' was the all-satisfying reply. He was a most efficient contracts engineer and helped things forward in many backward parts of the world. He married happily about retirement time but leaves no family.

He joined The Institution as a Student in 1903 and was elected an Associate Member in 1911 and a Member in 1925. W. G. H.

PAPERS AND MONOGRAPHS

published individually this month

PAPERS

Papers accepted for reading at meetings and monographs are first published individually and are republished later in the Proceedings of The Institution; as soon as the separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition reprints of papers read at meetings including the discussions thereon and of papers not read at meetings become available, price 2s., within two months of their appearance in the Proceedings.

Applications quoting the serial number of the paper, monograph or reprint as well as the author's name and accompanied by a remittance where appropriate should be addressed to the Secretary of The Institution. For convenience books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually are urged—if they do not take the Part of the Proceedings in which it will be republished—to apply in due course for a reprint as this is the final and correct version and includes the discussion.

Quadrature network for generating vestigial-sideband signals *Paper* 3054E: *Part B*

G. G. GOURIET *and* G. F. NEWELL

THE authors describe a method of generating an approximate quadrature signal from a given signal using a linear network comprising a tapped delay line. A vestigial-sideband signal free from phase distortion can be produced by this means.

An experimental version of the quadrature network discussed has been constructed, and the paper includes the results obtained using the network to produce a vestigial-sideband version of a 405-line television signal with a video bandwidth of 3 Mc/s.

It is suggested that a high-power vestigial-sideband signal could be produced by this means with some saving in transmitter power.

To be read on the 11th January 1960

Generator/motor problems in pumped-storage installations *Paper* 2853S: *Part A*

J. H. WALKER, M.SC., PH.D.

THE author investigates the problems in pumped-storage installations relative to the electrical ratings of the generator/motor units and the possibility of using two-speed synchronous machines for this duty.

For those cases where the set runs in the opposite direction of rotation when pumping to that when generating the paper discusses the difficulties in starting the set on the pumping cycle, the design of the thrust bearing and the arrangement of the ventilating system.

Frequent stopping is a characteristic of pumped-storage stations, and it is advisable to supplement the action of the friction brakes by a simple form of dynamic braking.

To be read on the 11th November 1959

Application of irradiation in industry *Paper* 3145U: *Part A*

M. C. CROWLEY-MILLING, M.A.

TYPES of radiation and methods of production are surveyed. A detailed examination is made of engineering problems involved in applying irradiation to industry. Economic aspects are considered.

To be read on the 5th November 1959

Some properties of travelling-wave resonance *Paper* 3031E: *Part B*

J. R. G. TWISLETON, B.SC.

MR. TWISLETON presents an analysis of travelling-wave resonance in a waveguide ring fed through a directional coupler. The theory allows for equal propagation constants for the ring waves or for a different propagation constant for one of the waves and for a reflecting discontinuity in the ring; it describes the behaviour of the ring-wave ratio and the reflection and transmission in the feeder in the neighbourhood of resonance.

A method of investigating the ring resonance using a travelling probe is discussed, and experimental results are given for the case of equal ring-wave propagation constants which substantiate the theory. The employment of a travelling probe clearly illustrates the properties of travelling-wave resonance.

To be read on the 9th November 1959

Saturation effects in a travelling-wave parametric amplifier *Paper* 3017E: *Part B*

A. JURKUS, B.SC.A., *and* P. N. ROBSON, B.A.

THE equations governing the voltage distribution along a parametric travelling-wave amplifier can in certain conditions be solved in terms of elliptic functions.

The solution shows that there is a spatially periodic transfer of energy between the signal, idling and pumping waves. The maximum saturated power gain that can be achieved is:

$$1 + \frac{\omega_1}{\omega_3} \frac{\text{pump input power}}{\text{signal input power}}$$

where ω_1 and ω_3 are the angular frequencies of the signal and of the pump respectively. The positions of these gain maxima can be calculated explicitly without invoking small-signal conditions.

To be read on the 9th November 1959

Some comments on the classification of waveguide modes *Paper* 3132E: *Part B*

A. E. KARBOWIAK, B.SC.(ENG.), PH.D.

THE author presents in so far as possible non-mathematical language the concepts of modes currently in use. Some of the concepts are modified or generalized, and a unified description is obtained. The term 'proper-mode' is reserved for a certain mathematical concept which is usually concomitant with that of the eigenfunction, while the term 'quasi-mode' is reserved for a field configuration which can be supported by a physically realizable guiding structure.

In the description given the radiation field which it is shown must always accompany a guided wave is viewed in a novel light, and a bridge is fashioned between the concept of modes guided in closed waveguides and that of those guided by open structures.

The existence of guided waves is discussed, and it is demonstrated that whether a mode exists or not is entirely a matter of subjective opinion (implicit in the definitions). It is nevertheless shown that all quasi-modes are a physical reality and that they are useful in practical applications.

To be read on the 2nd November 1959

Submersible pumping plant *Paper* 3147U: *Part A*

H. H. ANDERSON, B.SC., *and* W. G. CRAWFORD, B.SC.

SUBMERSIBLE pumping units have been developed to a sufficiently high degree of reliability and efficiency to capture a large part of

Papers and monographs published individually this month (continued)

the field previously held by the conventional borehole pump with surface motor. A description is given of the submersible pump and the submersible motor as separate units, and sectional drawings, constructional details and performance characteristics are presented.

An investigation is reported of the efficiency, testing and behaviour of the pump and motor in abnormal and transient conditions of starting, zero-head operation and reverse rotation; and details are included of the energy dissipation and the turbine phases of the pump and of the runaway speeds attained in reverse rotation. The question of the optimum diameter of the pump-set and borehole for supply installations is examined from the economic point of view, and the implications of corrosive waters are studied.

Problems relating to the linkage of pump and motor include the radial and axial loadings from pump-to-motor thrust bearings, the effect of these loadings in producing upthrust and downthrust and the motor-starting torque.

To be read on the 12th November 1959

Research on the performance of high-voltage insulators in polluted atmospheres *Paper* 3014s: *Part A*

J. S. FORREST, M.A., D.SC., P. J. LAMBETH, B.SC.(ENG.), *and* D. F. OAKESHOTT, B.SC.

THE authors report the research carried out at the Croydon Insulator Testing Station during the last 15 years on the performance of insulators in humid and polluted atmospheres.

Various types of line and substation insulator have been investigated, and the results obtained with working voltages up to 380 kV are presented. Methods of surface treatment to improve performance are discussed. Work on experimental insulators made from plastics is described. An account is given of recent research on high-voltage d.c. operation. The use of artificial salt-pollution tests to simulate service conditions is considered.

To be read on the 13th November 1959

MONOGRAPHS

Discrimination between h.r.c. fuses and miniature circuit-breakers *Monograph* 345U

H. D. EINHORN, DR.-ING., PH.D.

THE aims and merits of protective devices for low-voltage installations are reviewed. The joint use of h.r.c. fuses and miniature circuit-breakers is functional in many installations. The hypothesis that the 0·01 sec fusing current provides a criterion for discrimination is subjected to experimental tests, and the statistical nature of discrimination is analysed.

Practical conclusions for installation design are reached, and a new fuse series and various other methods for backing-up miniature circuit-breakers are suggested.

Use of silicon diodes in d.c. modulators and their applications to drift correctors for computing amplifiers *Monograph* 346M

T. GLUCHAROFF, M.E., *and* C. P. GILBERT, M.SC.

THE basic computing element of an electronic analogue computer is the high-gain d.c. amplifier, but in order to overcome its inherent drift some form of auxiliary drift-correcting amplifier is frequently employed.

The authors describe a silicon-diode modulator for use in such drift correctors The zero stability which can be achieved is comparable with that given by the conventional relay modulator. The diode circuit results in a number of improvements in the over-all drift-corrector performance such as a higher frequency response and practically unlimited life. The design of such a drift corrector for a given d.c. amplifier is considered in detail, and its performance is assessed.

Conductivity of oxide cathodes. 7—Solid semiconduction *Monograph* 347E

G. H. METSON, M.C., D.SC., PH.D., M.SC., B.SC.(ENG.), *and* E. MACARTNEY, M.SC., B.SC.

THE properties of the solid conductivity state below 600°K are considered. For comparison the conductivity at 420°K is given the title 'low-temperature reference conductivity σ_{420}', and this function is studied in relation to its environment. It is found that σ_{420} increases in almost linear fashion with increase of conditioning temperature and that it also increases with increase of chemical activity of the core metal. At constant temperature σ_{420} is invariant over a wide range of applied voltage and current and shows a high order of stability with time.

Perhaps the most surprising result to emerge is the observed vulnerability of the solid conductivity to low-pressure-oxygen attack even at a temperature as low as 300°K.

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned except where otherwise stated.

BRITISH BROADCASTING CORPORATION

Engineering Division Monograph No. 25 **A quality-checking receiver for v.h.f./f.m. sound broadcasting** by C. G. Mayo and R. E. Jones. 5s.

THE development of the receiver is described, and results of tests on the original and final prototype models are given. Both have a high standard of performance, the main advantage of the final model being its simpler design.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

Second supplement to Report W/T 33 **The relationship between relative humidity and the moisture content of agricultural products—preliminary report** by P. Finn-Kelcey and D. G. Hulbert. 6s.

THE report together with the first supplement were reviewed in the October 1958 *Journal*, p. 563. The second supplement contains further experimental results.

BRITISH STANDARDS INSTITUTION

B.S. 350: Part 1: 1959 **Conversion factors and tables.** Part 1 – Basis of tables. Conversion factors. 15s.

THE revision of B.S. 350 when completed will cover, broadly, units, their abbreviations, conversion factors and detailed conversion tables for a wide range of subjects under the headings metrology, mechanics and heat. Part 1 gives extended basic information on units and their abbreviations. Comprehensive tables show the relationship between any two of the British and metric units used in the measurement of a given physical quantity.

B.S. 741: 1959 **Flameproof electric motors for conveyors, coal-cutters, loaders and similar purposes, for use in mines.** 5s.

THE revised British Standard deals with constructional requirements (referring to B.S. 229 'Flameproof enclosure of electrical apparatus') and electrical performance including permissible temperature rise.

Technical publications (continued)

performance under momentary overloads and at high voltage, commutation, efficiency and power factor. There are many changes from the previous (1937) standard.

B.S. 2509: 1959 **Periodicals of reference value.** Form and presentation. 6s.

THE Standard covers data for identification, format, indexes, annotation of supplements, reports of meetings, etc. and is chiefly meant for those who edit or contribute to scientific, technical and other periodicals used for reference over a long period.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Research for industry 1958

THIS is a report of work done by the industrial research associations which are aided by the Government grant scheme.

The main achievements of ten whose grant has come up for renewal and outstanding news items from others are included. For instance the Electrical Research Association is to have a new laboratory for research on the creep and rupture properties of steels for use at high temperatures of interest to the electrical and allied industries.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE

Fire research 1958 Report of the Fire Research Board with the report of the Director of Fire Research. H.M.S.O., London, 1959. 5s.

IN the section dealing with electrical fires an interim report on a survey carried out from September 1957 to August 1958 to obtain information to indicate ways of retarding the uniform increase of fires with electricity consumption states that of 7000 electrical outbreaks 2000 were caused by wire and cable, the remainder by apparatus. Of domestic heaters electric types are seven times more prone to cause fire and oil four times more than an open fire for an equivalent amount of useful heat.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH: BUILDING RESEARCH STATION

Factory building studies No. 2 **Lighting of factories** by M. J. Keyte and H. L. Cloag. London, H.M.S.O., 1959. 3s. 6d.

THIS is a general survey divided into two sections, the first setting out the general principles of good lighting and the second discussing their implications in the design and maintenance of factories.

INSTITUT FÜR HOCHFREQUENZTECHNIK ZÜRICH

Mitteilungen aus dem Institut für Hochfrequenztechnik Nr. 25 **Untersuchunger über Frequenzstabilisation im Mikrowellengebiet** (Examination of frequency stabilization in the microwave region) by A. Brändli. Verlag Leeman, Zürich, 1958. 8s. 6d.*

WRITTEN in German the report covers stabilization in general; stabilization of a reference frequency; the equal-arm discriminator; and experimental performance.

NATIONAL BUREAU OF STANDARDS

Journal of Research of the National Bureau of Standards

THIS publication is now (since July 1959) appearing in four sections which can be subscribed for individually. Section A, Physics and chemistry, is issued six times a year and the annual subscription is 32s. (approx.); Section B, Mathematics and mathematical physics, is issued quarterly for an annual subscription of 18s.; Section C, Engineering and instrumentation, also quarterly, costs 18s. annually; and Section D, Radio propagation, is issued six times a year for an annual subscription of 32s. Each part will contain, in addition to those of the Bureau's research reports which are relevant, review articles by recognized authorities, abstracts of other N.B.S. articles, and a list of N.B.S. publications not abstracted.

Applied Mathematics Series 56 **Tables of osculatory interpolation coefficients** by H. E. Salzer. 3s. (approx.)*

SUPPLEMENTS previous tables of interpolation coefficients published in the same series.

Circular 599 **On the theory of fading properties of a fluctuating signal imposed on a constant signal** by H. Bremmer. 2s. 6d. (approx.)*

THIS is a mathematical examination of the varying strength of a radio signal consisting of two components: a constant signal and a fluctuating signal of the same frequency which has reached the receiver by a different path. The fluctuating signal is first considered as a random, then as a quasi-random result of first-order scattering in a turbulent atmosphere.

PERGAMON PRESS

Electrochimica acta — Vol. 1, No. 1 £6 per volume

THIS new journal which will contain original communications in the field of pure and applied electrochemistry has been launched under the auspices of the International Committee for Electrochemical Thermodynamics and Kinetics (C.I.T.C.É.). It will contain papers presented at C.I.T.C.É. conferences, other original papers (not necessarily from members of C.I.T.C.É.), short letters to the editors, and a list of current papers on electrochemistry.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

Fifth annual report 1958–59 H.M.S.O., London, 1959. 5s.

IN addition to a summary of the authority's activities and financial record for the year the report includes a review of progress made during the last five years on the applications of nuclear energy with reference also to developments outside the United Kingdom. The objectives of the authority's reactor-development programme are stated. At the Press conference introducing this report it was disclosed that the effects in Zeta, the toroidal apparatus for the study of thermonuclear processes in which deuterium gas is raised to very high temperatures, are not fully understood and that a more basic approach is to be made with a new machine known as I.C.S.E. (intermediate current stability experiment).

UNITED NATIONS

Development of hydro power stations on the Danube—existing, under construction or projected United Nations, Geneva, 1959 1s.†

THE document presents data concerning 44 hydroelectric schemes existing, in course of planning or projected along the main stream of the Danube and includes both national stations and joint installations situated on common frontiers of riparian countries.

UNITED STATES DEPARTMENT OF COMMERCE

N.E.L. reliability bibliography Supplement 2. U.S. Department of Commerce, Washington, 1958. 18s.‡

COMPILED by members of the U.S. Navy Electronics Laboratory, San Diego, the basic volume appeared in May 1956. Pages in this supplement are numbered for insertion in the relevant sections.

* Obtainable from the publishers Verlag Leeman, Arbenzstrasse 20, Zürich 34, Switzerland

* Obtainable from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.
† Obtainable from the Sales Section, European Office of the United Nations, Palais des Nations, Geneva, Switzerland
‡ Obtainable from the Office of Technical Services, Department of Commerce, Washington 25, D.C.

SOME RECENT BOOKS

P. AGERON, A. BONALDI, N. GAUZIT and T. REIS (*Editors*)

TECHNOLOGIE DES RÉACTEURS NUCLÉAIRES

EYROLLES. 1959. 568 PP. £7

THIS first volume of a series is devoted to the materials of nuclear reactors. After the first two sections on basic physics the authors describe the preparation, properties and uses of a fairly comprehensive selection of substances.

The first article by T. Reis, intended to introduce the non-specialist to reactor physics, is confused and contains several factual mistakes and incorrect definitions which are inexcusable. The chapter by N. Gauzit on the interaction of radiation with matter is discursive and often superficial. The same criticism applies to most of the section on fissile and fertile materials by T. Reis and A. Bonaldi though parts are in concise note form. Tables of empirical results are presented without accuracies or references.

Chapters 4–7 by A. Bonaldi on non-fissile substances are the most satisfactory. The style is homogeneous, and tables are well documented. Shielding and constructional materials are reviewed by P. Ageron. The style is good, but again accuracies and bibliography are lacking.

Some of the articles contain long lists of useful references though the considerable amount of British work receives scant mention. On the whole the book is adequate but not to be commended to English-speaking scientists as better texts exist.

J. M. CARROLL

MODERN TRANSISTOR CIRCUITS

McGRAW-HILL. 1959. 268 PP. £3 6S.

THIS is a collection of 101 articles published in *Electronics* in 1956–58. They are by different authors, each is complete in itself and there is no connecting thread between them so the whole is essentially a work of reference rather than a textbook.

The range of topics covered is extremely wide. In addition to descriptions of amplifiers, oscillators, power-supply units, pulse circuits and computer equipment there are sections on telemetry, medical applications, industrial control, television and so forth. Instruments for inclusion in artificial satellites are described and so is an ultrasonic oscillator which can be clipped to the back of a salmon so that when the fish is released its subsequent motion can be tracked.

One of the most ingenious things is a transmitter built into a capsule 0·9cm in diameter and 2·8cm long which can be swallowed. As the capsule passes through the gastro-intestinal tract it radiates information concerning the local temperature and pressure!

The contributions are well indexed, and most of them include diagrams and complete details of components. The circuits are designed round transistors available in the United States, and British readers will need to make the appropriate modifications.

This stimulating book will be welcomed by anyone who wishes to look up a transistor arrangement for a particular job or is seeking information about the latest uses for these devices.

R. A. CHARPIE and J. V. DUNWORTH (*Editors*)

SOVIET REVIEWS OF NUCLEAR SCIENCE (INTERNATIONAL SERIES OF MONOGRAPHS ON NUCLEAR ENERGY—DIVISION 2. NUCLEAR PHYSICS VOL. 3)

LONDON: PERGAMON PRESS. 1959. 108 PP. 30S.

THIS volume's eight reviews of different aspects of atomic energy were written in November 1957 and are to some extent outdated by material published later at Geneva II and elsewhere.

The reviews are (1) 'Development of atomic energy in the Soviet Union' (N. A. Nikolaev); (2) 'Uranium on graphite reactor and superheated steam power stations' (D. A. Dolezhal); (3) 'Graphite in nuclear reactors' (V. V. Goucharov); (4) 'Efficiency of atomic power stations' (I. I. Novikov); (5) 'High-energy particle research with the synchrocyclotrons of the Laboratory of Nuclear Problems at the Joint Institute for Nuclear Studies' (V. P. Dzhelepor and B. M. Pontecorvo); (6) 'Interaction of slow neutrons with nuclei' (V. V. Vladimirsky and others); (7) 'Use of radioisotopes in the U.S.S.R.' (G. V. Kurduyomor and others); and (8) 'Soviet radiochemistry' (A. N. Murin).

Your reviewer found the first four articles decidely dull but (5) and (6) well worth reading. (7) covers a wide range of radioisotope applications and is interesting in showing what a large amount of scientific work has been done in Russia. (8) is mainly historical.

S. J. COTTON

MATHEMATICS FOR TELECOMMUNICATIONS ENGINEERS

CHAPMAN AND HALL. 1959. 245 PP. 37S. 6D.

THE author has set out to fill a gap among available textbooks of mathematics for students of telecommunication engineering, and he has adopted much of the language commonly used by engineers. Thus he represents $\sqrt{-1}$ by j and perhaps a little loosely calls a complex quantity a vector.

The early part dealing with differential and integral calculus, determinants, expansion of series, and trigonometrical and complex functions follows the traditional pattern but includes a number of electrical examples of the principles discussed.

The second half brings together in an easily assimilated form many of the specialized mathematical techniques applicable to telecommunication problems. It discusses network theory, functions of a complex variable, harmonic analysis in its application to passive networks, vector analysis, Laplace's equation, Bessel functions, probability and statistics. To cover that ground adequately is a formidable task, and perhaps as might be expected it is not all done with the high standard of precision and clarity which marks most of the volume.

For example there should be a negative sign in equation (7.2) indicating that the current is positive when the rate of change of voltage is negative. In Fig. (10.3) counterclockwise rotation is used for the x, y, z sequence of space co-ordinates, and the expression for B_r is incorrect. The calculation of the amplitude of the fundamental component current $i(t)$ on p. 165 appears to be in error.

The section on Bessel functions appropriately calls attention to the problem of frequency modulation as one of the applications of these functions, but no numerical example is given nor is reference made to the other important case of electromagnetic waves propagated in tubular waveguide.

Whatever criticisms can be levelled against the treatment in detail there can be no doubt about the success of the volume as a whole. It was written by an engineer for engineers, and they will undoubtedly find it of value. Both the author and the publishers are to be congratulated on their achievement.

G. A. CHAPPEL

RADIO STATIONS—INSTALLATION, DESIGN AND PRACTICE

LONDON: PERGAMON PRESS. 1959. 248 PP. £2 10S.

THIS work is packed full of sound common sense with enough facts and basic theory to give a good structure on which to build that common sense. It is very readable in spite of its concentrated form. The author is obviously well experienced in all the pitfalls of the art.

It should be of value to the young engineer who is taking up installation work or to the older engineer who finds himself involved in such work as a side-line. Nowadays even the experimental engineer is liable to have to deal with large amounts of apparatus which often have to be erected on a remote site. He then becomes concerned with the technique of installation which is really not his main task. This book should stimulate such a person's understanding and allow him to devote more time to his principal function.

Possibly an established installation engineer would not learn much from the volume, but he might find a copy useful to lend to his new assistants who would probably then buy a copy for themselves.

H. EICHNER and H. HEIN

READING GERMAN FOR SCIENTISTS

CHAPMAN AND HALL. 1959. 207 PP. 30S.

THE authors disclaim any intention of attempting to do more than teach the student to read technical German. They therefore concentrate on the written language and emphasize only the grammar required to construe modern scientific German. The illustrative material from the very beginning is used to introduce the vocabulary of chemistry and physics.

Given that German courses on these lines are common, books of this type are needed and this one is useful, but a less utilitarian approach might well provoke more interest and be of greater educational value. The title is much too wide—the biological sciences and engineering are not included.

H. N. GANT

MOBILE RADIO TELEPHONES

CHAPMAN AND HALL. 1959. 125 PP. 21S.

IN the author's preface this volume is described as a guide to the user of equipment and an attempt to explain the meaning of the terms and specifications likely to be found in manufacturers' literature. This is an excellent description, the book being neither more nor less than claimed.

It deals in four chapters with the uses and limitations of mobile radio equipment, performance requirements, installation, maintenance and testing. In all sections only a limited technical knowledge is assumed. It is well indexed but has no bibliography, owing no doubt to the lack of comparative publications at this technical level. It is quite well written and should be interesting and informative to the intended reader.

L. LANDON GOODMAN

AUTOMATION TODAY AND TOMORROW

NEWMAN NEAME. 1959. 158 PP. £2

THIS is an excellent general survey of the development of automation in British industry up to 1957 or 1958. Developments in America and Russia are included. Since almost the whole range of manufacture is covered the book cannot go into detail, and it is therefore likely to be of most help to the manager or senior executive who wishes to see what has been done in other industries which might be applicable to his own. It is to be hoped that it will be used in this way because it is full of common sense concerning automation and does not try to over-sell it.

Inevitably some of the descriptions are sketchy but are of value in indicating the amount of complexity that can be economic. It might have been better to have given as appendices fuller descriptions of some of the examples in chapter 16. Goodman is to be congratulated on getting such a large amount of information and comment into such a small space and in a style that is easy to read.

The second half is a complete bibliography of the automatic factory comprising 854 titles and particularly useful because a brief synopsis is given of each entry. This bibliography makes the whole an excellent record of the present state of the art and a fine introduction to the subject.

The format is good, and the printing and paper are of high quality. Anyone interested in the field will certainly like to have this work on his shelves.

A. HECHT

ELEKTROKERAMIK

BERLIN: SPRINGER-VERLAG. 1959. 269 PP. £4

THIS book is concerned to a large extent with the design of high-voltage insulators. After a brief discussion of the chemical constitution of porcelain, steatite and the titanate dielectrics there are chapters on the manufacturing processes of body preparation, shaping, firing, glazing and metallizing, on the properties, principally mechanical, of the ceramic, on standard testing procedures, a very detailed section on the design of insulators and finally a chapter on applications.

There is some neglect of the electrical properties, particularly of the dielectric ceramics, in favour of the mechanical properties, but this is perhaps not surprising in view of the fact that the bulk of the industry's production consists of porcelain insulators whose mechanical strength is of paramount importance.

The text is on the whole well written though some parts are decidedly long-winded. Read with discrimination it may form a useful introduction for the student, while the more detailed matter will give the expert a picture of modern German practice.

L. K. KIRCHMAYER

ECONOMIC OPERATION OF POWER SYSTEMS

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1958. 260 PP. £4 16S.

IN the design and operation of power systems, as in the field of engineering generally, electronic computers are providing

solutions to problems which were previously too complex to tackle. An example is the making of calculated allowances for transmission losses in power-system load-dispatching, with which this volume is mainly concerned. The methods described are in use in the United States where, it is claimed, such allowances can yield typical annual savings of $50000 per 1000 MW of generating capacity.

The text covers work done by the author and others during the past decade, much of the material having been published previously in separate papers. It gives a clear exposition of the theory of economic system operation and shows by means of actual examples how the theory has been applied in certain American networks. The use of matrix algebra in deriving transmission-loss coefficients, developed from the fundamental work of G. Kron, is treated carefully and in considerable detail, as is also the co-ordination of incremental transmission losses with incremental production costs for optimum economy. As the merits of transmission-loss-formula techniques are not without controversy however, more space might with advantage have been devoted to methods for the direct calculation of transmission losses.

The book is intended for use as a graduate course in power-system engineering. It should prove valuable to advanced students and, more particularly, to qualified engineers who are practising in this specialized field.

K. P. KOVÁCS and I. RACZ

TRANSIENTE VORGANGE IN WECHSELSTROM-MASCHINEN—VOLS. 1 and 2

BUDAPEST: AKADÉMIAI KIADÓ. 1959. 784 PP. £2 12S. 6D. (approx.)

THIS is a comprehensive study of the transient behaviour of 3-phase synchronous and asynchronous machines. The first volume deals with basic principles and with transients in synchronous machines while the second discusses transients in asynchronous machines. Although the treatment is mainly mathematical the physical nature of transient phenomena is explained. The work should prove useful to the advanced student as a unified and up-to-date treatment of a subject which is often covered only in isolated articles while the practising engineer will find it a valuable source of reference.

The chapter on basic principles includes an investigation of transients in simple circuits; an account of the various vector systems for representing current, voltage and flux; the definition of machine inductances; and a general calculation of machine torques. This is followed after a brief section on synchronous-machine steady-state performance by an analysis of transient currents and torques during symmetrical and asymmetrical short-circuit on cylindrical and salient pole machines with and without damper windings.

Tests for obtaining the various machine reactances are described, and an equivalent circuit for the current and voltage harmonics which occur during asymmetrical short-circuit is presented. The dynamic stability of single- and two-machine systems, hunting, the influence of voltage regulators on transient behaviour, starting, asynchronous operation and synchronizing of synchronous machines are examined.

The survey of asynchronous machines considers transient voltages, currents and torques which arise while switching on and off, during changeover switching, and after sudden short-circuits.

The text is well illustrated. Numerical examples show the use of various equations. A bibliography and tables of transient constants for typical machines are appended.

Y. H. KU

ELECTRIC ENERGY CONVERSION

NEW YORK: RONALD PRESS. 1959. 522 PP. £3 10S.

VIEWS about electrical machine analysis have changed markedly during the past ten years. The machine is recognized as a link between mechanical and electrical energy systems and not as an isolated device with characteristics adequately described in terms of simple steady-state parameters. As a result there has been a succession of textbooks recently, mostly of American origin, dealing with the dynamics of a wide range of electrical-mechanical-magnetic systems and devices and their energy states. The title of this work suggests that it, too, is in the sequence: in this respect the title is misleading.

This is actually a publication of the author's considerable work on the transient analysis of synchronous machines and induction machines and on varieties of 3-phase system components. It is thinly clad with some further material extending the scope but with a rather uneven effect: in fact the author seems to have little interest outside his field. An introduction called 'Principle of conservation of energy' outlines nuclear fission and fusion and a few other energy transformations.

The main text opens with a discussion of electro-mechanical energy conversion, not notably well done. Maxwell's equations and the Poynting vector are introduced here but are not applied—nor even referred to—anywhere else. The treatment of commutation is scrappy and obscure, and there are many other mistakes or incoherencies suggesting not ignorance but lack of interest on the author's part. Other evidence of a cobbled patchwork is found in the swithering between M.K.S. and C.G.S. units and the lack of a clear theme.

Advanced workers will probably appreciate the core of the volume on transient analysis and the numerical examples. The author's colleagues provided him with 100 problems and their answers, but the answers are not passed on to the reader.

W. D. LAWSON and S. NEILSON

PREPARATION OF SINGLE CRYSTALS

BUTTERWORTH. 1959. 279 PP. £2 5S.

THIS is an attempt to review the various techniques at present in use for the manufacture of single crystals, with special reference to semiconductors. Some of the general principles involved in the construction of equipment for growing single crystals from the melt are outlined. The means available for the purification of the raw materials are described, and the methods commonly used for analysing these materials are surveyed. Much space is devoted to the theory of crystal growth and lattice defects.

Unfortunately the authors have tried to include rather too many aspects of the present technology for a book of its size, and as a result some significant matters receive rather superficial treatment while others are hardly even mentioned. Despite the title for example the space devoted to the description of essential techniques such as vertical pulling and zone levelling is relatively small, and too much attention is perhaps paid to methods which have not found widespread industrial application.

Similarly, few practical details of the necessary metallographic and other ways of appraising crystal quality are given. At the same time other topics receive rather more consideration than their present practical importance demands

which imparts a somewhat theoretical flavour to the work. Consequently it is difficult for the uninitiated reader to obtain a true picture of the present state of the art.

For these reasons the volume is likely to be of limited value to the qualified engineer who is not a specialist. It may however provide a useful introduction for those embarking on work in this field provided that it is read with discrimination.

E. McCRENSKY

SCIENTIFIC MANPOWER IN EUROPE

LONDON: PERGAMON PRESS. 1958. 188 PP. £2

THE author attempts to furnish 'meaningful information and concepts on the better management and use of scientists in the public service', based on personal visits to all the important countries carrying on advanced scientific work except the Soviet Union.

Throughout, the terms science and scientist include technology and technologist, and a scientist is anyone engaged on pure or applied science, including research and development and research administration. The author's concept of a scientist is as the prototype of a modern man in a modern government which will want to use the special resource of his personal experience at the highest possible useful level.

A great deal of valuable information is given about the selection of scientists, their recruitment, rewards and status in the community, and on various schemes for joint consultation. Of special interest is the high status accorded to university professors in countries like Switzerland, Germany and the Soviet Union and the way this enhances the reputation of the universities in these countries.

It is outside the scope of the book to deal with practical training, and more emphasis is placed on the education of the scientist and his place in society than on that of the engineer.

There is an interesting chapter on the higher education of engineers and on the British experiments at Cambridge and at the University College of North Staffordshire in teaching an appreciation of science to arts undergraduates and cultural subjects to all undergraduates. It would have been interesting to learn of similar experiments in other countries. A comprehensive bibliography is included.

W. R. MYERS

THEORETICAL ELECTROMAGNETISM

BUTTERWORTH. 1958. 274 PP. £2 2S.

THE principles of electromagnetism occupy a central position in the teaching of electrical engineering and physics, and quite a number of suitable expositions are available to the student. The importance of the subject and the existence of good textbooks make it essential for the author of a new work setting forth these principles to achieve a high standard to make his contribution worth while. Unfortunately this volume does not reach such a standard.

The student with a practical bent will find the book intolerable as the theory is hardly ever anchored to anything solid or tangible. The author frequently remarks that 'experiment shows that . . .', but these experiments are even more remote than the famous 'thought-experiments' of German physicists. He may be writing for those who hope to become theoretical physicists, though even these will find the book unsatisfactory.

He is not sure of the nature and purpose of scientific explanation, and his style is diffident and apologetic. A typical example is the enigmatic sentence 'There is no reason to doubt the truth of these results even though they appear to conflict with our intuitive ideas, because the examples we have chosen are fundamentally impracticable'.

The author is happier with symbols and equations than with words, and his most effective chapter deals with electrostatic problems. There is also a welcome but not entirely successful attempt to give an introduction to waveguides.

The text is attractively produced; unfortunately in the reviewer's copy pp. 197–212 lie between pp. 180 and 181.

G. NEWSTEAD

GENERAL CIRCUIT THEORY

METHUEN. 1959. 144 PP. 15S.

THIS useful little book covers a surprisingly large amount of ground. Almost every major aspect of circuit theory receives mention, including topics such as transient response and non-linear analysis. This is achieved through concentration on the development of general relationships rather than the detailed analysis of particular circuits. The style is lucid, and no previous familiarity with the topic is necessary.

A natural limitation of the text is the failure, at times, to call attention to the practical importance of a concept. A notable example is the section on gyrators, which leaves the reader with the impression that *passive* non-reciprocity is a mere curiosity; a brief reference to microwave isolators would have dispelled this idea. These are minor shortcomings however, which do not detract from the work's general value. It should prove of special use to those whose interest or degree of specialization does not justify the purchase of a more voluminous treatise.

C. H. PAGE

THE ALGEBRA OF ELECTRONICS

VAN NOSTRAND. 1959. 258 PP. £3 6S.

HERE is a general introduction to circuit theory at a level demanding no more than a knowledge of elementary algebra and simple differential calculus. The subjects discussed include general network theroems, the practical solution of simultaneous equations, capacitance, inductance, complex numbers, a.c. networks, impedance matching, diode characteristics, amplifiers (principally valve), noise, modulation, demodulation and distortion. Each chapter is illustrated by set problems to which answers are given.

The volume will be valuable to the reader who possesses limited mathematical aptitude or finds certain concepts difficult to grasp but nevertheless has the will to learn. Dr. Page is a well known author, teacher and physicist, and he writes competently and clearly in a style singularly free from the jargon and chatty digressions which plague so many American publications of this sort. The usefulness of the book to the student will be limited only by the extent to which it may fail to cover the syllabus of a particular telecommunication course.

A. I. PRESSMAN

DESIGN OF TRANSISTORIZED CIRCUITS FOR DIGITAL COMPUTERS

NEW YORK: RIDER. 1959. 324 PP. £3 10S.

HERE is a book that has long been overdue: an authoritative and excellently written account of the possible approaches to transistor logical circuitry for digital computers. Written for the

practising computer designer, it also caters for the newcomer to the field. A good introduction to the philosophy of logical circuitry is given, followed by a brief introduction to transistor fundamentals as relevant to switching circuits.

A discussion of diode gates leads into the main text, which deals with the design and performance assessment of logic schemes involving the use of transistor inverting amplifiers in conjunction with voltage-switching diode gates, current-switching diode gates and resistance logic; direct coupled transistor logic is also considered. Throughout this treatment particular emphasis is laid on 'worst case' design for the required speed of response, and the analysis leads to assessment of the minimum pyramiding factors of the logical building blocks examined. Included in this material are methods of achieving high circuit-response speed, notably anti-saturation techniques.

Then follows a review of other approaches to transistor logical circuitry, some recently proposed, including gated-pulse logic and emitter-follower current switching: a fairly detailed description is given but with less authority than in the earlier chapters. The work ends with a chapter on flip-flop (bistable multivibrator) design, mainly concerned with the Eccles–Jordan type of circuit.

The volume is strongly recommended to the professional computer designer and also to those who wish to acquire a general appreciation of the ways in which transistors may be applied in computers. The text is very readable, the breezy style seeming particularly appropriate to the subject-matter.

D. H. D. ROLLER

THE DE MAGNETE OF WILLIAM GILBERT

AMSTERDAM: MENNO HERTZBERGER. 1959. 196 PP. £6 12S. 6D.

DR. William Gilbert of London and Colchester, physician and philosopher, died in 1603, three years after the publication of his treatise 'De magnete'. As he was one of the earliest exponents of the experimental method and author of the first treatise based on it, his work has an easily discernible influence. However interest in him quickly lapsed and was not revived until the end of the 19th century when, within eight years, the only two English translations of 'De magnete' were produced and Prof. S. P. Thompson made the first recorded researches into Gilbert's life and family. Since then historians have shown a growing but sporadic interest in him. Publications about him have been few and widely scattered. The only other translation of 'De magnete' is in Russian and was published in 1956.

Dr. Roller's book which is based on a doctoral dissertation presented at Harvard is the most comprehensive account of Gilbert's life and work that has yet appeared. It is in traditional form, dealing in sequence with the state of knowledge of magnetism and electricity before Gilbert; Gilbert's life; his work on electricity, magnetism, navigation and cosmology recorded in 'De magnete'; and its influence.

It reflects a careful study of published data. The author's critical approach is welcome as the sparseness of the material available has often led previous writers to dilute their facts with plausible fiction, although the circumstance that Dr. Roller worked a long way from London and Colchester has led to one or two trifling blemishes.

It is meticulously documented but lacks an index which would have been valuable. It should be in any library that devotes space to the history of science. It will give a flying start to anyone beginning further research on the subject.

S. SESHU and N. BALABANIAN

LINEAR NETWORK ANALYSIS

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 571 PP. 1959. £4 14S.

DESCRIBED as a first-year graduate-level textbook on network theory this is the fruit of its author's teaching experience. Presupposing some knowledge of the Laplace transform, function theory and matrix algebra it covers most of the topics arising in network analysis including steady-state and transient response, gain-phase relationships, elementary feedback theory, two-part parameters and topological considerations together with some topics arising in synthesis, notably realizability conditions, Chebȳshev approximation and image-parameter filter theory.

On the whole the choice of material is sensible and the explanation adequate. The grade of treatment is a little uneven: in England, at least, an engineer or advanced student who can appreciate the more sophisticated parts will find the presentation in other places naïve and on occasion long-winded, while the chatty style seems inappropriate at times. To sum up, this is an addition to the rather large number of textbooks written with general competence though without any real distinction, and it is noteworthy chiefly for its coverage of a fairly wide range of topics in one volume.

C. V. L. SMITH

ELECTRONIC DIGITAL COMPUTERS

McGRAW-HILL. 1959. 443 PP. £4 13S.

IT is a feature of most American books on computers that the authors seem unaware that much of the pioneer work was carried out on this side of the Atlantic. Dr. Smith's scholarly work is a happy exception to this rule and has the additional merit of being written in a style which is easy to read and devoid of the spurious philosophizing into which many attempts to describe digital computers fall.

The basis of the text is the system of computer logic devised by von Neumann at Princeton, and many of the circuits described are those of the Princeton machine. In this respect the author has done a considerable service to designers since the material is otherwise available only in privately circulated reports.

Chapter headings are: digital-computer arithmetic; instruction codes, general considerations on systems; basic logic circuits and their representation; static memory cells; dynamic memory cells; higher-order logic circuits; shifting registers; counters; adders and accumulators; large-scale memory devices—1; large-scale memory devices—2; the arithmetic unit; the memory; the central control; input and output; and superspeed computers.

Both the expert and the tiro will find something of interest in the volume, which can be unreservedly recommended.

L. D. SMULLIN and H. A. HAUS (*Editors*)

NOISE IN ELECTRON DEVICES

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 413 PP. £4 16s.

AMONG the considerable literature which has recently become available on the general topic of noise, very little has been published on the application of the theory to electronic devices. The editors of this volume have gone a long way to remedy this defect. As stated in the preface the work does not purport to be a definitive treatise on the subject of valve and

transistor noise. Wisely, it is restricte d to a limited number of topics examined by authors who are well known in their particular fields.

It opens with a discussion of the effect of shot noise from thermionic cathodes followed by a comprehensive section on flicker noise in valves. Three chapters dealing with noise in electron beams in grid-controlled valves and travelling-wave tubes complete the part devoted to valve noise. The two final sections are concerned with semiconductor noise and transistor noise.

The main shortcoming is the unfortunate lack of continuity; each chapter is written as a separate entity. In consequence there are a number of instances of repetition and an unfortunate lack of consistency in symbolism which, despite the editors' assertions, could have been avoided.

The value of the book extends beyond the main factual content as the reader is provided with examples of the application of the majority of mathematical techniques at present available in this field.

P. F. R. VENABLES

SANDWICH COURSES

MAX PARRISH. 1959. 160 PP. 18s.

THIS volume appears at a most opportune time. There is a tendency to regard sandwich courses as a cure for all industrial evils. The warning in chapter 2 that they should be established only after full consultation with industry is apt.

The contributed chapter on aspects of industrial training deals too much with craft and technician apprentices, while recent developments in professional training in which the electrical engineering industry has played a leading part are hardly mentioned. At times the fact that a sandwich course is a partnership course with industry and college taking equal responsibility is not sufficiently stressed; sandwich courses thrive only when this relationship exists. The reference to 'end on' courses (p. 101) shows a failure to grasp the nettle: expansion can take place only with the full support of industry, and industry can only support if courses are 'end on'—this simple fact must be accepted.

A wealth of information about the present position is given which will be of particular help to headmasters and others responsible for the guidance of school-leavers.

W. EARL STEWART

MAGNETIC RECORDING TECHNIQUES

McGRAW-HILL. 1958. 272 PP. £3 6s.

THE first impression one receives is that 50% of the subject-matter is taken directly from various articles in scientific journals, manufacturers' data and published American Standards for magnetic recording. It seems a pity to take up space in this way, and one feels that the more important references should have been given in précis form. It is unfortunate for the European reader that no detailed attention is paid to standards other than American. The International Electrotechnical Commission is not even mentioned. Nevertheless one finds a great deal of good and detailed information on both the design of equipment and its operation.

The discussion of the operation of a.c. bias is weak and unsatisfactory. The chapter on the tape transport system is too short, though the advice and general information are excellent and should be of great value to the would-be designer. The description of recording and replay characteristics contains most of the important facts and gives a reasonable analysis of the subject.

The account of tape-manufacturing methods is interesting and surprisingly detailed considering that this part of the technique is usually guarded with great secrecy by various tape manufacturers, but more information is needed on the nature of the magnetic particles and the physical operation of the magnetic process. The important point is that the individual particles are small enough to be of single-domain size, and a cluster of these particles are said to be magnetized when they are magnetized substantially in the same direction and demagnetized when there is complete randomness in their direction of magnetization.

One is glad to see that adequate space and emphasis have been given to the explanation of the various response losses in tape such as spacing loss, thickness loss, etc.

The book will be extremely useful to engineers taking up the subject of magnetic recording for the first time and to those already possessing considerable experience.

J. R. WAIT

ELECTROMAGNETIC RADIATION FROM CYLINDRICAL STRUCTURES

LONDON: PERGAMON PRESS. 1959. 200 PP. £2 10s.

CONFINED to just one aspect of electromagnetic radiation, this is an attempt to suggest how the performance of flush-mounted aerials in missile structures may be inferred from a consideration of the behaviour of such aerials in and about cylindrical surfaces. The author's conception of a cylindrical surface is very wide, being extended to cover corner reflectors, wedges, half-planes and, of course, elliptical cylinders, so that the volume is of more general interest than might at first be imagined.

Although the work includes some radiation patterns of which use may be made directly, it consists mainly of various mathematical approaches to the radiation problems and demands of the reader a sound knowledge of functions normally associated with 'advanced' electromagnetic theory. The treatment, however, is full, drawing amply on modern analytical methods; and while complete results, for obvious reasons, are confined to the more simple special cases, sufficiently general results are derived to enable solutions to be found with the aid of a computer.

The discussion is supported throughout by an excellent bibliography containing over 100 references. The whole of the appendix could with advantage be read initially as an introduction to the book, as it contains many of the basic definitions used without further explanation in the text, such as that of the special 'Hertz vector' on which much of the treatment is based.

G. G. WAKEFIELD (*Editor*)

AIRCRAFT ELECTRICAL ENGINEERING

CHAPMAN AND HALL. 1959. 349 PP. £2 10s.

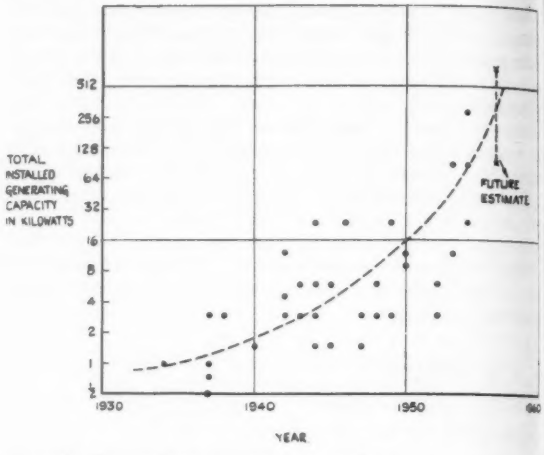
PUBLISHED under authority of the Royal Aeronautical Society, the accuracy of the matter included is beyond question. Editorially the arrangement is less satisfying, and among the distinguished authors contributing there is much overlapping and variation in both technical and literary standard. Many minor errors occur, more with some authors than others, and apparently in the writing rather than in the printing. Production is excellent with a generous index and bibliographies.

Readers studying aircraft electrical engineering might be advised to start with chapter 10, 'Electrical power systems', 30 pp., followed by chapter 12, 'System operation and protection', 34 pp., which is a valuable addition to the scarce literature on this subject. Then the sections on a.c. and d.c. machines, batteries, and switchgear, all very informative, would fall into place.

'Introductory survey' and 'Future trends' do little more than reiterate what is included under the principal heads and could therefore be combined and reduced or omitted in a revised edition. The chapters on 'Cooling of aircraft electrical machines', 'The physical causes of high-altitude brush wear' and 'Environmental conditions and functional requirements' are of considerable value for general reference and design consideration, but the last mentioned might preferably be condensed and given as an appendix. The section on 'Vibration' is innocent of any guide to the design of anti-shock and anti-vibration mountings.

The chapter on wiring, 'Electrical installations engineering', 56 pp., is rather below the general standard, containing besides much verbiage a lot of data which should be available gratis from manufacturers or in official specifications; it could well be restricted to an account of modern good practice and future needs to satisfy a student or general reader. Several volumes could be written on the last 20 years of aircraft wiring to little purpose save as a warning for the future.

As probably the only really adequate book on the subject published in Britain it would be well worth the time and effort required to fashion it into a more coherent treatise of uniform style. Standardized symbols should be used wherever possible.



Growth of generating capacity in aircraft

LIBRARY ACCESSIONS

* *Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BOOKS

ACTON, F. S. 519.2

Analysis of straight-line data

New York: Wiley. London: Chapman and Hall, 1959. pp. xiii, 267. 23·4 × 15cm. £3 12s.

Deals with the analysis of experimental data that can be described in terms of linear relationship.

BABANI, B. B. 621.385

International radio tube encyclopaedia. 3rd edition

London: Bernards, 1958. pp. lxxxiv, 410. 26 × 19cm. £3 3s.

Gives the operating characteristics and pin connections of more than 27 500 tubes.

BOGOLIUBOV, N. N., TOLMACHEV, V. V., and SHIRKOV, D. V. 537.312.6

A new method in the theory of superconductivity

New York and London: Consultants Bureau, 1959. pp. iii, 121. 22·5 × 15·5cm. £2 10s.

This work, originally published in Russian in 1958, is a highly theoretical treatment of interest to the mathematical physicist.

BRADLEY, E. N. 621.314.7

British transistor manual

London: Norman Price, 1959. pp. 222. 22·5 × 15cm. 12s. 6d.

Data covering British transistors including type, manufacturer, dimensions and characteristics are given.

CHAPPEL, G. A. 621.396.61

Radio stations: installation, design and practice*

London: Pergamon Press, 1959. pp. viii, 248. 22 × 15cm. £2 10s.

A practical work dealing with every aspect of the planning, design and erection of small radio stations. It contains many photographs and drawings illustrating constructional features of buildings, equipment, masts, etc. and useful data. This book is reviewed on p. 603.

CORROSION PREVENTION AND CONTROL 620.19

Anti-corrosion manual. 1959 edition

London: Corrosion Prevention and Control, 1959. pp. lxxviii, 326. 29 × 21cm. £3

Contains a series of short survey articles on corrosion, corrosion-resistant materials and protective coatings. Includes also a buyers' guide and a list of relevant British Standard specifications and patents.

DEUTSCHE VERBUNDGESELLSCHAFT 621.311

Entwicklung des Verbundbetriebes in der Deutschen Stromversorgung (Progress in the unification of German power-supply undertakings [1948–1958])

Heidelberg: Deutsche Verbundgesellschaft, 1959. pp. 92. 30 × 21cm. n.p.

KAUFMANN, H. 538.551

Dynamische Vorgänge in Linearen Systemen der Nachrichten- und Regelungstechnik (Dynamic processes in linear systems of communication and control)

Munich: Oldenbourg, 1959. pp. 211. 24 × 16cm. £2 12s.

Deals with transient phenomena and pulse techniques.

KNOLL, M. 621.385.032

Materials and processes of electron devices*

Berlin: Springer-Verlag, 1959. pp. xiii, 484. 25 × 17cm. £5 13s. 6d.

This book is a most comprehensive treatment of the subject with over 2000 bibliographical references including patents. It is based in part on 'Werkstoffkunde der Hochvakuumtechnik' by Espe–Knoll published in 1936 but obviously includes much more recent information. It deals with the preparation and working of materials used in vacuum tubes and semiconducting devices and manufacturing techniques especially those relating to the vacuum. To be reviewed.

MENDELSSOHN, K. (*Editor*) 536.48

Progress in cryogenics—Vol. 1

London: Heywood, 1959. pp. vii, 259. 25·5 × 15·5cm. £3 3s.

The first volume in a new series which will consist of articles surveying the whole field of low-temperature technology and applications in various branches of physics.

PARR, G., and DAVIE, O. H. 621.385.832

The cathode-ray tube and its applications. 3rd edition*

London: Chapman and Hall, 1959. pp. xii, 433. 22 × 14cm. £2 10s.

Deals briefly with the theory and design of the electron gun. Power supplies, amplifiers, time-bases and other associated circuits are considered more fully. Applications in radar, computers, electron-switching tubes, and television are discussed.

PULLEN, K. A., Jun. 621.385

Conductance design of active circuits

New York: Rider, 1959. pp. xiii, 330. 23 × 15·5cm. £4

Describes the use of conductance curves in the design of valve and transistor circuits, considering the circuits in terms of a combination of their small-signal and static or d.c. behaviour. Reviewed in August 1959 *Journal*, p. 479.

ROLLER, D. H. D. 93:537

The *De magnete* of William Gilbert

Amsterdam: Hertzberger, 1959. pp. 196. 26·5 × 19cm. £6 12s. 6d.

This is a most thorough and scholarly study of the famous book 'De magnete' written by William Gilbert in the reign of Queen Elizabeth I. It reviews the state of knowledge of electricity before Gilbert, his own work and observations on the subject and the various editions of his book in which he set down his conclusions. It also surveys what is known of Gilbert's life from records and relics which have been preserved. This book is reviewed on p. 606.

SHEPHERD, G. (*Editor*) 691

The insulation handbook

London: Lomax Erskine, 1959. pp. 130. 22·5 × 15cm. 10s.

Data on thermal and sound insulation material and anti-vibration mountings.

WHITE, D. C., and WOODSON, H. H. 621.313

Electromechanical energy conversion*

New York: Wiley. London: Chapman and Hall, 1959. pp. xv, 646. 24 × 15cm. £5

An advanced and comprehensive treatment. Primarily concerns rotating electrical machines but includes a discussion of transducers and feedback control systems. Reviewed in August 1959 *Journal*, p. 481.

WYLEN, G. J. VAN 536.7

Thermodynamics

New York: Wiley. London: Chapman and Hall, 1959. pp. xxiii, 567. 23·5 × 15cm. £3 4s.

This book is intended to give the undergraduate student an appreciation and understanding of both the physical and the mathematical aspects of thermodynamics.

ZADE, H. P. 679.5

Heatsealing and high-frequency welding of plastics

London: Temple Press, 1959. pp. xii, 211. 22·5 × 14cm. 35s.

Deals mainly with the properties of thermoplastics and techniques of welding these materials but gives some information on the welding equipment.

OTHER PUBLICATIONS

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

4th biennial A.I.E.E. conference on electric heating. Papers presented at the A.I.E.E. conference on electric heating, Philadelphia, 14th–15th April 1959

New York: American Institute of Electrical Engineers, 1959. pp. 128. 28 × 21·5cm. $3.50

Electrical engineering problems in the rubber and plastics industry. Papers and discussions presented at the 10th A.I.E.E. conference on electrical engineering problems in the rubber and plastics industry, Akron, Ohio, 14th–15th April 1958

New York: American Institute of Electrical Engineers, 1958. pp. 150. 28 × 21·5cm. $4.00

Materials handling conference. Proceedings of the A.I.E.E. materials handling conference, Pittsburgh, 19th–20th May 1958

New York: American Institute of Electrical Engineers, 1958. pp. 112. 28 × 21·5cm. $4.00

3rd national conference on analog and digital instrumentation, 20th–21st April 1959, Bellevue-Stratford, Philadelphia

New York: American Institute of Electrical Engineers, 1959. pp. 279. 28 × 21·5cm. $5.00

1959 national telemetering conference. Papers presented at the A.I.E.E.–I.S.A.–A.R.S.–I.S.A. national telemetering conference, Denver, Col., 24th–27th May 1959

New York: American Institute of Electrical Engineers, 1959. pp. 411. 28 × 21·5cm. $6.50

Proceedings of the computers in control systems conference presented at Atlantic City, N.J., 16th–18th October 1957

New York: American Institute of Electrical Engineers, 1958. pp. 189. 28·5 × 21cm. $3.50

Proceedings of the 1959 electronic components conference, Philadelphia, 6th–8th May 1959

New York: American Institute of Electrical Engineers, 1959. pp. vii, 231. 28 × 21·5cm. $7.50

Proceeding of the western joint computer conference. Contrasts in computers. Presented at Los Angeles, Calif., 6th–8th May 1958

New York: American Institute of Electrical Engineers, 1959. pp. 244. 28·5 × 21cm. $4.00

ASSOCIATION INTERNATIONALE DE CYBERNÉTIQUE

1st international congress on cybernetics, Namur, 26th–29th June 1956. Proceedings

Paris: Gauthier-Villars, 1958. pp. xxv, 923. 25 × 15cm. £5

AUSTRALIAN ATOMIC ENERGY COMMISSION

Australian atomic energy symposium 1958. Proceedings of a symposium on the peaceful uses of atomic energy in Australia held in Sydney from the 2nd to 6th June 1958

Australia: Melbourne University Press, 1958. pp. xi, 788. 25 × 19cm. n.p.

Library accessions (continued)

BROOKS, H. (*Editor*)

Advances in semiconductor science. The proceedings of the third international conference on semiconductors held at the University of Rochester, U.S.A., 18th–22nd August 1958

London and New York: Pergamon Press, 1959. pp. ix, 533. 25·5 × 19·5cm. £5

GENERAL POST OFFICE

Private mobile radio services

London: H.M.S.O., 1959. pp. 38. 15 × 12cm. 2s. 6d.

UNITED NATIONS

Proceedings of the second United Nations international conference on the peaceful uses of atomic energy, held in Geneva 1st–13th September 1958. Vol. 10—Research reactors

Geneva: United Nations, 1958. pp. viii, 548. 29 × 22cm. £6 14s. 3d.

Proceedings of the second United Nations international conference on the peaceful uses of atomic energy, held in Geneva 1st–13th September 1958. Vol. 11—Reactor safety and control

Geneva: United Nations, 1958. pp. viii, 550. 28·5 × 22cm. £5 11s.

Proceedings of the second United Nations international conference on the peaceful uses of atomic energy, held in Geneva 1st–13th September 1958. Vol. 14—Nuclear physics and instrumentation

Geneva: United Nations, 1958. pp. ix, 491. 28·5 × 22cm. £6

Proceedings of the second United Nations international conference on the peaceful uses of atomic energy, held in Geneva 1st–13th September 1958. Vol. 17—Processing irradiated fuels and radioactive materials

Geneva: United Nations, 1958. pp. ix, 709. 28 × 22cm. £6 9s.

Proceedings of the second United Nations international conference on the peaceful uses of atomic energy, held in Geneva 1st–13th September 1958. Vol. 23—Experience in radiological protection

Geneva: United Nations, 1958. pp. ix, 453. 28·5 × 22cm. £5 4s.

Elections and transfers

The following elections and transfers approved by the Council are effective from the 1st September 1959

ELECTIONS

Associate Members

BARKER, Alfred John, B.A.
BARKER, Geoffrey George, B.SC.
BERMAN, Barnett Donald, B.SC.(ENG.)
BIBB, Douglas McKinley
BIGGS, James Edward
BLAMIRE, John
BRIGGS, James Ronald, B.SC.(ENG.)
BRUELL, Robert Erwin, B.SC.(ENG.)
CAMERON, Arthur Hugh
CROYDON, Lt. John Edward Kenneth, B.A., R.N.
FALCONER, John Ernest Anderson
FENSOM, Harry William
GARLAND, Sqdn.-Ldr. Dennis John, B.SC., R.A.F.
HENDRY, Eric Douglas, B.SC.
HICKMAN, Michael James, M.A.
HUNTER, Desmond, B.SC.
McKEOWN, John
SMITH, Lt. Donald Henry, M.SC., R.N.Z.N.
VARMA, Gopal Krishna Ram, B.SC.(ENG.)
WELCH, Anthony Hugh, B.SC.(ENG.)
WILKINS, Peter Granville
WITHERS, Frank Edward, B.SC.

Associates

COVENEY, Donald Scott
GALLAGHER, John Campbell
GOLDER, Jack Alexander
PEACOCK, George Edward

TRANSFERS

Associate Member to Member

BAKER, Leslie Frederick Montague, B.SC.(ENG.)
BROWN, Herbert Stuart, B.ENG.
BRUNKER, Alfred John, B.SC.(ENG.)
BRYAN, Tony, B.SC.(ENG.)
DAVIS, Lionel Thomas
DEVENISH, William Henry
FLACK, Dennis Clifford, B.SC., PH.D.
FOSTER, William Henry
FURBER, Harold Darrell, D.F.H.
GILL, Thomas, B.SC.
GLEDHILL, Frederick George, B.SC.
HALL, Fred, B.SC.TECH.
HORNER, Frederick, M.SC.
MARSHALL, Tom Audley Hylton, M.A.
MELLOR, Harry Whittaker, B.SC.
PLOWMAN, Ashley Sheridan
PRESTON, Col. George Neil, R.E.M.E.
WOODS, Oswald

Associate to Associate Member

HARROWER, John
OVERTON, Frank Gregory
YIRRELL, Ernest William Frederick

Graduate to Associate Member

AHMAD, Nasim, B.SC.(ENG.)
ALLCOCK, Peter David
ANSTEY, Kenneth William
BACKER, John
BARNES, Norman
BARTLE, John, B.SC.(ENG.)
BATLEY, Charles Trevor
BAXTER, Kenneth
BEAN, William Sydney
BLAKE, James Henry
BRIDGE, John James
BRIGHT, Alfred William, B.SC.(ENG.), PH.D.
BROWN, John, B.SC.(ENG.)
BROWNRIDGE, William Strachan
BUCKLEY, Ruth Victoria, PH.D., B.SC.
CHAPMAN, Anthony Hubert, B.SC.(ENG.)
COATS, Constantinos Charalambous, B.SC.(ENG.)
COCKRAM, David Frederick, B.SC.(ENG.)
COOKE, Brian
CULL, Gerald James
DAVIS, Alfred George
DAVISON, Elder Brian, B.SC.(ENG.)
DAWE, Alan Clifford, B.SC.(ENG.)
DRAKE, Terence Theodore, B.SC.(ENG.)
EASTON, James Campbell, A.R.C.S.T.
EWINGTON, Harold
FIELD, Peter William
FIGG, David John
FINLAY, Donald James, B.SC.(ENG.)
FIRTH, Frank Leslie, B.SC.(ENG.)
FORREST, Alexander Crighton
FULLER, David John
GALANIDES, Athos Renou, B.SC.(ENG.)
GREGSON, Ernest Leslie
GRICE, Sidney Pearson
HAGGIS, John Brian
HARVEY, Robert Valentine, B.SC.
HAVENITH, Fernand Joaquim Jean Marie, D.F.H.
HENDERSON, John, B.SC.
HILL, Daniel Robertson, B.SC.
HOGAN, Robert Vivian, B.SC.(ENG.)
HORTON, Bertram
HUGGETT, Instr.-Cmdr. Geoffrey, B.SC.(ENG.), R.N.
HULL, Pamela Margaret
JUMP, Kenneth
KEMP, Charles Edwin David
KERSLAKE, Philip Herbert, B.SC.(ENG.)
KIMBER, Colin Spencer
KNOWLES, John Richard
LANDER, John Eaton, M.A.
LAYCOCK, Samuel Mackenzie
LEDGER, Frank, B.SC.(ENG.)
LEE, Chye Watt
LIGHTBODY, Eric William, B.E.
LINFORD, Gordon
LORENZO, Edward
McLOUGHLIN, Columcille Aloysius, B.SC.
MACMURRAY, Charles Henry, B.SC.
MATHEW, Cheruthotathil Joseph Mathew, B.SC.(ENG.)
MEASURES, Robert Edward, B.SC.
MILIANOWICZ, Stanislaw Adam
MORIARTY, Dermot Kevin
MURRAY, Brian Richard Neil, D.F.H.
NAYLOR, Ronald, M.SC.
OSBORNE, George James
PETERSON, Leonard Percival
PRESTON, Douglas Stuart George, B.SC.
ROSE, William Edwin, M.ENG.
ROSS, Gilbert Hamilton
SEELEY, John Scott, B.SC.(ENG.), PH.D.
SIMPSON, Kenneth
SMITH, James Cadzow
SOMERVILLE, Michael John, B.SC., PH.D.
SOUTHERN, Christopher John
STRIPP, Hamilton Aubrey
TAYLOR, John
THOMPSON, Austin Rex, B.SC.
THOMSON, David Alexander, B.SC.
TIGHE, Robert William, B.SC.
URRY, Peter Geoffrey, B.SC.
VENABLES, William Alfred
WAYNE, Josef
WRIGHT, Cecil Scott

Student to Associate Member

McDONALD, Patrick Anthony, B.SC.

The following elections and transfers approved by the Council are effective from the 17th September 1959

ELECTIONS: 1st LIST

Graduates

ALLAN, Geoffrey Frank Leslie
BARDELL, Colin Dudley
BENNETT, Peter Graham
BURSELL, Robert Arthur
CLARKE, Richard Henry, B.SC.(EKG.)
CONROY, Ernest William
COPE, Maurice
DAVIS, Desmond Rhodes, B.SC.
ECCLESTON, Wallace Dudley, B.E.E.
EVANS, Leonard
FEDOSIUK, Michael
FISHER, John Geoffrey
HYDE, Kenneth
HYMANS, Anthony Jack
KAY, Norman Roy, B.E.E.
KIRKBY, Capt. Kevin
LIM, Koang Eng, B.SC.(ENG.)
LUCAS, Patrick Bryan
MARKS, Trevor Ernest
MATTHEWS, William Donald
MORRISON, George Sprott
NAIR, Rajinder Kumar, D.F.H.
OSBALDESTON, Alfred John, B.SC.
PARROTT, John Noel
PRESS, Harold Davison
SILCOCK, Michael Roy Wallis, B.SC.
SINGH, Kartar
STANLEY, Walter
TUAKLI, Latekoe Adebowale
WYATT, Norman

Students

ALDISS, David Varnell
ANGEL, Colin
BETTERIDGE, Laurence John
BINKS, Norman
BORMAN, John Brian
BROWN, Reginald William Viney
CAHALANE, James Bernard
CHETTRI, Tekbahadur, B.E.
COULBECK, Bryan
DAS, Jagdish Chander, B.A., B.SC.(ENG.)
DAVIS, Leonard George
DEAN, John Leslie
DEPLEDGE, Kenneth William
EDWARD, Henry Artin, B.SC.
ESTEVES, Jose Jorge Lopes
FAIRCLOUGH, Henry Christopher Anthony
FRASER, Neville Noel
GORDEMER, David
GRICE, Peter Anderson
HELSBY, Lawrence Eric
HINDLEY, Peter John
HOWARTH, Christopher Clive
IBALL, John Elwyn
KEARSEY, Roger Patrick
KING, Christopher Simon Overton
KINVIG, Eric Roger
LAIN, Richard
LINGARD, Peter
MANN, Robert Ernest
MARTIN, Colin Lewis
MITCHELL, Peter Stewart
NALIKKA, Henry
OWEN, Stanley David
PALING, Brian Thomas
PALMER, David Stuart
PALMER, Gordon Sidney
PAPADOPOULOS, Takis Zacharia
PASSEY, Francis Bennett
PATHMANATHAN, Somasundram
PHILPOTT, Ronald George
REID, Bernard Edsell
RICHARDS, Wynne
ROBSON, John Edmund
ROSSON, Allen Stuart
STEWART, Patrick Alexander Hallett
STUART, Allan Ernest Garth
TAMBIPILLAI, Samuel George Kuneratnam
TEMBY, Allen Christopher
THEIN, Frederick, B.SC.(ENG.)
WADDELL, Michael
WELSH, Alan William
WILCOCK, John Slider
WILLIAMS, John Cyril
WRIGLEY, David

TRANSFERS: 1st LIST

Student to Graduate

ASHA, John Bryan
BETTS, John Arthur, B.SC., PH.D.
COWARD, Philip Ronald, B.SC.(ENG.)
DATE, Madhav Waman, B.SC.TECH.
DAVIES, Hywel
FIELD, Allan James Michael, B.SC.(ENG.)
HOARE, Leonard Ronald Victor, B.SC.(ENG.)
HOLLAND, Geoffrey Thurston
HOLMES, Ronald William, B.SC.(ENG.)
JENKINS, William Eric
LAWTON, Bryan
LINLEY, Barrie Dale, B.SC.TECH.
MALKANI, Kishin Hassomal, D.F.H.
ROBINSON, Ian Walker, B.SC.
THOMAS, Alun David
WRIGHT, Gordon

ELECTIONS: 2nd LIST

Graduates

ADBY, George Colin
ASHDOWN, Denis Edward, B.SC.
BENSON, Marcel Lawrence, B.E.
BETTLEY, Neville John
BHAGWAT, Purushottam Ramchandra B.SC.
BINGHAM, John Anthony Clifton, B.SC.

Graduates (continued)

BRADBURY, Peter, B.SC.
BRYSON-HAYNES, Donald
BURT, Ronald Norman, B.E.
BUZACOTT, John Alan, B.SC., B.E.
CLEPHAN, Michael, B.SC.
COMELIO, Terry Bernard, B.SC.
COOKE, Malcolm John Stansfield, B.A.
COUSINS, Alga Keith, B.A.
DAVID, Ellis, D.F.H.
DOBSON, Austin Theodore
DOWLING, Denis William, B.E.
DUTT, Robindra Nath, B.SC., B.SC.(ENG.)
ELDER, Mark Alexander, B.E.
FAULKNER, Alec Richard, B.E.
FIDELL, Michael Alan, B.SC.
FOSTER, Lt. Peter Arthur Nedham, B.A., R.N.
FULTON-FORREST, Keith Patrick
GARDNER, William
GOULD, Peter Maxwell, B.SC.(ENG.)
HACOBIAN, Tigran
HALL, John Phillip, B.E.E.
HANBY, Daniel Arthur Fernand
HARTLEY, David, B.ENG.
HUTCHINSON, David Stuart, B.A.
INGRAM, Ian Frederick
JAYAWICKRAMA, Priya Padma, B.SC.
JAYENDRAN, Ariacutty, B.SC.
JENKINS, Maldwyn Trevethan
KAVANAGH, Brian Matthew John, B.A., B.SC.
KILBRIDE, Ronald
KITCHEN, David John
LENNON, Leo
LITTLE, Robert Frankland
LUKE, David McGregor, B.SC.(ENG.)
MANNING, Justin James, B.E.
MAVRO, Mosko
MECIDOGLU, Pertev
MORRIS, Brian George Richard, B.SC.
NAGARAJAH, Ramappillai, B.SC.
NEWMAN, Anthony James, B.SC.
NOAD, George James
OUVRY, Anthony Philip Delahaize, B.A.
PALMER, Brian Ivan, B.SC.(ENG.)
PHILIP, Patrick Blake, B.SC.
REYNOLDS, George Stanislaus, B.E.
ROBSON, Edward
SANDER, John Emil, B.ENG.
SEARS, Raymond Eric John, B.SC.
SINGHASIRIWEERA, Kamburugamuwe Gamacharige
SMITH, David Anthony, B.SC.
SMITH, Kenneth
SMITHERS, Roy Charles, B.SC.(ENG.)
STARK, Donald Herbert, B.E.E.
STURLEY, Cyril William
SWEPSON, Graham
TAMM, Eero, B.SC.(ENG.)
TOBEY, Richard, B.A.
UN, Kenneth Ki-cheung, B.ENG.
UNDERWOOD, Ralph Desmond
WHARAM, Robert Geoffrey
WHEATLEY, John Edward
WILLIAMS, Philip John Albert
WILSON, James
WOODGATE, John Michael B.SC.(ENG.)

Students

ABROOK, George Edward
AMARASINGHAM, Yogendiran
ANSDELL, Arthur Anthony
BALASUBRAMANIAM, Thambippillai Vaithialingam
BALDWIN, David Arthur
BIRKBY, John William
BOOTH, Tony Frederick Stephen
BOTTOMLEY, John Howard
BOWN, Rodney James Chandler
BOWSKILL, David John
BRIGGS, Alan
BURTON, Godfrey Raymond
BYRNE, Francis
CARR, Grahame Robinson
CHALKER, David Michael Cyril
COLE, Arthur Richard John
CUNNINGHAM, Robert James
CURTIS, Brian William
DAVIS, Raymond Archibald
EAST, George Frederick
EDIRIWICKREMA, Elmo Bartholomew
ELISHA, Abraham
FOO, Cheng Theng
GIBBS, Norman Edward
GOH, Joon Kay
GOMES, Ashmore Hilary
GUNATILLAKA, Petikiri Arachchge Don Samarajeewa
GUNAWARDENA, Jaya Abeysingha
HAKEEM, Mohammad Amanul, B.SC.
HAMMOND, Roy Robert
HARDY-BISHOP, Brian Arthur
HAWLEY, David Alexander
HAWLING, Waclaw
HODGKINSON, Raymond Thomas
JACKSON, David Arfor
JACKSON, Maurice
JORDAN, James Redmon
JOSEPH, Joseph Ezekiel
KANCHANLAL, Krishnakant Kandoi, B.E.
KAPLAN, Wilfred Michael
KOH, Soo Seng
KRAJEWSKI, Mark
KWAN, Samuel Tse Cheng
KWOK, Chee Hong
LEVISTON, James Tony
LEWIS, Thomas Martyn Anthony
LIEW, Ter Kwang
LIM, Hoon Pheng
LONG, Brian Edward
LUNG, Chien Ping
MACDONALD, Donald John, B.SC.
MARLOR, James
MEAD, Arthur Thomas, B.SC.
MICHAEL, Ethelbert Victor
MONTGOMERY, Anthony Yalden
MORRIS, John Henry
NARULA, Mohindar Pal Singh, B.SC.
NEAL, Roger Edward
OWEN, Arthur Neville
PANDIT, Chennagiri Madhukar
PARDOE, Stuart Malcolm
PARSONS, Harry Brian
PHILLIPS, Brian Harry
POOLEY, Christopher
QAMARULLAH, Muhammad
QASSEMZADEH, Hassan
QUINN, Anthony
RAJANAYAGAM, Ilanganayagam
RAJKUMAR, Naganathy
REDDY, Hoody Peddanna Sundara Rama, B.E.
REED, Rodney Charles Ernest
REID, Ian McLeod
RUPASINGHA, Senani Parakrama De Silva
SALWAY, Roger Anthony
SANTHIAPILLAI, Arulanantham Gnanendrarasah
SANTHIRAN, Ganapathipillai
SARGANT, John
SAVILLE, Brian
SINGH, Malkit, B.SC.
SINHA, Nimai Charan, B.E.E.
SMITH, David Hilton
SMITH, David Lloyd
SMITH, Roger Keith
THARMALINGAM, Karthigesu
THE, Gregorius Maria Swie Siong
THIAGARAJAH, Subramaniam
THOMAS, Bruce MacAulay
TISSEVERASINGHE, Emil Aloysius Nicholas
TOLFREY, Ronald Joseph
TURNER, Michael John Bainbridge, B.SC.
VIVEGANANTHAN, Parampalam
WICKS, Stuart Edward
YIP, Seck Weng
YOUNG, Stewart Michael John

Elections and transfers (continued)

TRANSFERS: 2nd LIST

Student to Graduate

ANDERSON, Dennis
ARIYANANDA, Kamburugamuwe Lokuruge, B.SC.(ENG.)
ASHE, David Arnold, B.SC.
AYRE, John Kenneth, B.SC.
BEARD, Robert Victor
BOWTHORPE, John Willis, B.A.
BOXALL, Kenneth Percival, B.SC.
BRIERLEY, Peter, B.SC.
BROWN, Peter Kenneth
BRYDEN, Eric
BUCKLEY, Trevor, B.SC.
BURNS, Robert John
CHADWICK, Geoffrey Alan
CHARD, Walter Keith
CHEESEMAN, Roy Lawrence, B.SC.
CHETWYND, David Stuart
CLARKE, Roy Wellesley, B.SC.
CLEGG, John Corlett, B.ENG.
COLLINSON, Christopher David, B.SC.
COOK, Graham Arthur, B.SC.
COOPER, Brian Frederick, B.SC.
CORREIA, John Basil
CRYER, Derek Frank
DANDO, Graham
DAWES, Alan James
DEMPSEY, Thomas Anthony
DE SOUSA, Carlor Mussolini, B.SC.
DEVINE, Trevor James
DICKSON, John Graeme, B.SC.
DIXON, Ronald
DUCK, George William, B.SC.
DYER, Edward James
DYSON, Arthur Frank
ELLIS, George Robert, D.F.H.
FIELDING, Allan
FLETCHER, Michael Anthony, B.A.
FRANKLIN, Graham John
FREENEY, John Brendan
GOODENOUGH, Paul Douglas
GOULD, Reginald Dennis
GRIZZELL, Richard Laurence, B.SC.(ENG.)
HALLAM, Trevor James
HARTLAND, Brian John, B.SC.
HAWLEY, Robert, B.SC.
HENWOOD, Geoffrey Frederick, B.SC.
HEPPONSTALL, Bertram Rex, B.SC.(ENG.)
HESTAD, Odd Hallvard, A.H.-W.C.
HINDS, Charles Reginald
HOOK, George William
HUCKLE, Derek
HUNTLEY, Michael William Elliott
IVES, Charles Victor
JASKOLSKI, Andrzej Stefan
JESUTHASAN, Moses Daniel, B.SC.(ENG.)
KURUPPU, Upali Srimath, B.SC.(ENG.)
KWOK, Ping Ki
LAW, Peter Geoffrey
MAAS, Michael Jan, B.A.
MACDONALD, Malcolm Hugh, B.SC.
MARATHEY, Jayant Purandara
MARLOW, John Albert
MARSHALL, John Edward, B.SC.
MARTLEW, Allan
MICHELL, Michael Graham
MILLAR, Robert Mathieson Gemmell, B.SC.
MILLS, Michael Rudolph, B.SC.
MILNE, John Gilbert, B.SC.
MITCHELL, Terence, B.SC.
MORAGHAN, James Sylvester
OAK, Govind Gangadhar
PAGEDAR, Arvind Kamalakar
PATTEN, Arthur Robert Adrian
PELLY, Brian Raymond
PICHAI, Venugopal
PILBIN, Brian
PRINGLE, James Alexander Sharpe
RACKHAM, David John
RADHAKRISHNAN, Thangavelu, B.E.
RAMCHANDRAN, Karumanassery Parasuram
RANADE, Suresh Parashuram, B.E.
REICHER, George John, B.SC.
RICHARDSON, Julian
RINTOUL, John Howard
ROBERTS, Trevor John, B.SC.
SAGAR, Peter Alan
SHARPE, Terence Clifford
SHOREMAN, Derek, B.SC.
SHOTTON, John
SINGH, Naramolak
SLACK, Alan
SMITH, Albert Alan
SMITH, Michael Henry Arnould, B.A.
SPRING, Neil Frederick, B.SC.
SRIHARAN, Sivasambo, B.SC.(ENG.)
STICKLAND, William John
STOCKLEY, Robert Ezra James
TEO, Chye Poh, B.SC.
THAPAR, Baldev, B.A., B.SC.(ENG.)
THOMAS, Keith, B.SC.
THOMPSON, Raymond
TYSON, Edwin, B.A.
WAKEFIELD, John Robert
WHITAKER, George David, B.SC.
YOUNG, Peter Grafton Craig, B.SC.
ZUBAIR, Mohamed, B.SC.(ENG.)

The following elections and transfers approved by the Council are effective from the 1st October 1959

ELECTIONS

Associate Members

BAILEY, John Edwin, B.SC.
BANCROFT, George, M.A.
BENJAMIN, Kenneth Holloway, B.A.
BREARLEY, John Walter
CAIN, Alfred Edward
DOVE, Thomas Alfred
DUCKWORTH, Alan
FLETCHER, George Theodore
FRANTZIDES, Constantin
GABBITAS, David
GANGULY, Sunil Baran
GUNATILAKA, Gordon Hector Hugh
HARDEN, Billy Noel, M.SC.
HOUGH, George Hubert, B.SC., PH.D.
KEMP, Bernard George
MILLS, Geoffrey Lionel, B.SC.(ENG.)
PHILLIPS, Lionel Sidney, B.SC.(ENG.)
PIKE, George
RICKETTS, John Anthony
RIDLER, Maj. Mervyn Roy, B.SC., R.SIGNALS
ROWLES, Arthur Leonard, B.SC.
SEDDON, John, B.SC.(ENG.)
SIMPSON, Cmdr. Cortlandt James Woore, C.B.E., D.S.C., B.SC.(ENG.), R.N.
SZYMCZAK, Antoni, B.SC.(ENG.)
TASSICKER, Owen James, M.E.E.
TAYLOR, George Albert
THOMAS, David Tudor, B.SC.
TOMS, Brian Gerald, B.SC.
WHEATLEY, John Denis
WILLIAMS, Arfon Daniel, B.SC.
YARDLEY, Reginald Thomas
YOUNG, Vincent Robert, B.SC.

Companion

PAYNE-GALLWEY, Sir Reginald Frankland, BART.

Associates

CLARK, William
FERRIER, Malcolm Vincent
FRAME, Douglas Henry
GARBUTT, Walter Denis
SMITH, Samuel McGonnigal
WHITHAN, Frank
WILLIAMS, Ivor Llewellyn
WILSON, Andrew

TRANSFERS

Associate Member to Member

ABERCROMBIE, Stanley Douglas
ATKINS, Leonard Edward
BANCROFT, Thomas Frederick, D.F.H.
BARNES, Cyril Charles
CHAMPION, Lt.-Cmdr. Cuthbert Llewellyn, B.SC., R.N.V.R.
DENBON, Hubert Theodore
FUCHS, Georges, DIPL.ING., L.ÈS. SC.
GODDARD, Norman Sidney
GOLDSTAUB, Heinz Herbert, D.F.H.
HANWORTH, Lt.-Col. The Rt. Hon. The Viscount, B.A., R.E.
MACFARLANE, Charles John, B.SC.(ENG.)
MCKENNA, James Threlfall, B.ENG.
MARTIN, Lt.-Cmdr. George Henry Randolph, R.N.V.R.
MERCER, James Noel, B.SC.
RUTTER, Gordon
SHARAN, Swami, M.SC., PH.D.
SHAW, Thomas
SHIPP, Guy Emmerson, B.SC.(ENG.)
TEECE, John Harold Harwood, B.SC.(ENG.)
THEW, George Charlton, M.A.
WALKER, Harold Edward, B.SC.TECH.

Associate to Associate Member

ABBOTT, Percy William
KNUTTON, Lt.-Col. Harry, R.A.

Graduate to Associate Member

ASPLAND, John Lindsey
BAGE, Manohar Vithal
BAILEY, Douglas John
BARRETT, Ralph Lewis
BATTEN, Arthur Douglas
BOWHAY, George William, B.SC.(ENG.)
BROWN, Dennis Arthur
BROWN, Kenneth John, B.SC.(ENG.)
BROWN, Raymond
BURKWOOD, Henry Leslie Sidney
CAVE, Lt. Peter, R.N.
CHERRILL, Ronald Archibald
CLARKE, John Maynard
DAVIS, George
DEE, Geoffrey John
DIXON, Ronald
DONALDSON, John
DURRANI, Sajjad Haidar, M.SC.TECH.
DUTTA, Jagat Kumar, B.SC.
EARLS, John Crawford, B.SC.(ENG.)
ELIAS, Thomas Gwynn
FERRANTI, Basil Reginald Vincent Ziani de, M.A.
FIRTH, Donald
GARDNER, Lt. Kenneth Edgar, M.A., R.N.
GILBERT, Anthony James, B.A.
GOSLING, John Cedric, B.ENG.
GREEN, George Dennis, B.SC.
GUDGER, Leslie Albert
HALL, Richard Oliver, B.SC.TECH.
HARRIS, William Richard
HAYWARD, Ian Aubrey
HENDERSON, Henry Matthew
HEWITT, Eric John Robert, M.A.
HIGGENS, Kenneth Henry, B.SC.(ENG.)
HODGES, Maj. Stanley Osman Francis, R.E.M.E.
HONOUR, Vernon
HORNER, Keith
HORNSBY, Graham David, D.F.H.
HOUGHTON, Peter Alan, B.SC.(ENG.)
HOWARD, Ernest James
HOY, Harold Lamont
JACKSON, Wilfred Bruce, B.SC.(ENG.)
JEREMY, Kenneth William Charles
JOHNSTON, Colin David McKenzie, M.A.
JONES, Charles Francis, M.ENG.
KENNEDY, John, B.SC.
KIDNEY, Donald James, B.SC.(ENG.)
KLINE, Robert Allen, B.E.E.
KRAMER, Johannes Joachim
LARTER, Eric Stephen
LEIGH, Albert Peter
LYDIARD, George Frederick
MCGILL, William Maxwell Kirkpatrick
MANNING, Donald Bernard
MATTHEWS, Roy Ranger, M.A.
MEEK, Charles Raymond
MENZIES, Alan Douglas, B.SC.
MORTON, Capt. Douglas George William, R.E.M.E.
MURGATROYD, John Leonard, B.SC.(ENG.)
MYERS, Harry, B.ENG.
PICKEN, Geoffrey Houghton, B.SC.TECH.
PRICE, Harold
PRIESTLEY, John Alfred Edward
QASIM, Khalid, D.F.H.
REYNOLDS, John Frederick
ROACH, Bernard Mark
ROGERS, Edward Charles, M.SC.
SARJANT, Roy
SILCOCK, William
SLATER, Donald, B.SC.(ENG.)
SMART, Peter Denzil, B.SC.
SMITH, Horace Alexander, B.SC.(ENG.)
SPENCER, Arthur James, M.A.
SRINIVASAN, Aryanagipuram Kuppusami, B.SC.(ENG.)
STATT, Stanley
STEEL, Gerald Kirton
STEVENSON, Stewart Clifford
STOREY, William Allan
TERRY, Thomas Henry James
THOMPSON, Peter, B.SC.TECH.
WADE, George Moore, B.SC.
WALKDEN, Frank William, B.SC.(ENG.)
WARD, John, B.SC.(ENG.)
WATSON, Denis Welburn
WRAY, Robert William, B.SC.
YATES, James
YOUMANS, David Michael, B.SC.
ZARIM, Abu, D.L.C.

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place beginning at 5.30 p.m. (tea at 5 p.m.) except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and monographs published individually this month', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card

October 1959

S **21** *Wednesday* J. R. MORTLOCK, PH.D., B.SC.(ENG.) Chairman's Address 'Where next?'‡

M **27** *Tuesday* W. RENWICK, M.A., B.SC., will open a discussion on 'Future trends in memory stores for high-speed digital computers'†

E **28** *Wednesday* M. J. L. PULLING, C.B.E., M.A. Chairman's Address 'Development of Eurovision'‡

November 1959

E **2** *Monday* A. E. KARBOWIAK, B.SC.(ENG.), PH.D. 'Some comments on the classification of waveguide modes' (paper 3132E) *synopsis:* see p. 599 (supported by a contribution by L. LEWIN 'Some comments on quasi-optical methods at millimetre wavelengths'†)

M **3** *Tuesday* P. GLEGHORN, B.SC.(ENG.) 'An analogue electronic multiplier using transistors as square-wave modulators' (paper 2962M) *synopsis:* June 1959

O **5** *Thursday* M. C. CROWLEY-MILLING, M.A. 'The application of irradiation in industry' (paper 3145U) *synopsis:* see p. 599

MED **6** *Friday* H. J. EPSTEIN, F.F.A.R.C.S., *and* E. J. STEADMAN, B.SC., will open a discussion on 'Electronic and X-ray equipment for explosive atmospheres' (at 6 p.m., tea at 5.30 p.m.)

E **9** *Monday* PROF. A. L. CULLEN, PH.D., B.SC.(ENG.) 'Theory of the travelling-wave parametric amplifier' (paper 2991E) *synopsis:* August 1959; P. J. B. CLARRICOATS, B.SC.(ENG.), PH.D. 'The gain of travelling-wave ferromagnetic amplifiers' (monograph 334E) *synopsis:* May 1959; J. R. G. TWISLETON, B.SC. 'Some properties of travelling-wave resonance' (paper 3031E) *synopsis:* see p. 599; A. JURKUS, B.SC.A., *and* P. N. ROBSON, B.A. 'Saturation effects in a travelling-wave parametric amplifier' (paper 3017E) *synopsis:* see p. 599

M **10** *Tuesday* Section Dinner (at the Café Royal at 7 for 7.30 p.m.)

S **11** *Wednesday* J. H. WALKER, M.SC., PH.D. 'Generator/motor problems in pumped-storage installations' (paper 2853S) *synopsis:* see p. 599

U **12** *Thursday* H. H. ANDERSON, B.SC., *and* W. G. CRAWFORD, B.SC. 'Submersible pumping plant' (paper 3147U) *synopsis:* see p. 599

I **16** *Monday* E. L. E. WHEATCROFT, M.A., will open a discussion on 'Is off-peak load given sufficient encouragement?'*

M **17** *Tuesday* C. ADAMSON, M.SC.(ENG.), *and* E. A. TALKHAN, B.SC., PH.D., will open a discussion on 'Sequence networks versus summation transformers for the derivation of single quantities for protective relaying'†

S **18** *Wednesday* J. S. FORREST, M.A., D.SC., P. J. LAMBETH, B.SC.(ENG.), *and* D. F. OAKESHOTT, B.SC. 'Research on the performance of high-voltage insulators in polluted atmospheres' (paper 3014S) *synopsis:* see p. 600

ED **20** *Friday* T. SIKLOS, DIPL.ING., will open a discussion on 'The Ordinary National Certificate—a new look'* (at 6 p.m., tea at 5.30 p.m.)

E **25** *Wednesday* R. L. SMITH-ROSE, C.B.E., D.SC., PH.D. Lecture on 'Radio aspects of the International Geophysical Year'†

O **26** *Thursday* T. R. MANLEY, B.SC., K. ROTHWELL *and* W. GRAY 'The application of low-pressure resins to some high-voltage switchgear designs' (paper 2835S) *synopsis*: November 1959

* No advance information will be available, and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available

Contents of the current *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (OCTOBER 1959)

D. MIDGLEY, B.SC., PH.D. PAPER 3016U **A sliding-rotor induction motor** *October 1959*

L. B. S. GOLDS. PAPER 2863M, FEBRUARY 1959 **The influence of consumers' load-consumption characteristics on metering practice** *May 1959*

T. H. MASON, P. D. AYLETT, PH.D., M.SC.(ENG.), AND F. H. BIRCH, B.SC.(ENG.). PAPER 2846S, JANUARY 1959 **Turbogenerator performance under exceptional operating conditions** *April 1959*

F. S. FAY, M.A., J. A. THOMAS, B.SC., D. LEGG, B.SC., AND J. S. MORTON, B.SC. PAPER 2746S, NOVEMBER 1958 **Development of high-voltage air-break circuit-breakers with insulated-steel-plate arc chutes** *May 1959*

J. P. PITTS, B.SC.(ENG.). PAPER 2866, FEBRUARY 1959 **The reliability and life of impregnated-paper capacitors** *June 1959*

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (SEPTEMBER 1959)

SIR DAVID BRUNT, SC.D., F.R.S. PAPER 3035 The Fiftieth Kelvin Lecture on **The International Geophysical Year 1957-58** *June 1959*

Specialist discussion meetings on **New digital-computer techniques**

J. RHODES, M.B.E., B.SC.(ENG.). PAPER 3025E **A method of locating dry joints in telecommunication cables** *September 1959*

D. T. GJESSING, B.SC. PAPER 2789E, JANUARY 1959 **A simple investigation of the cross-modulation distortion arising from the pulling effect in a frequency-modulated klystron** *April 1959*

G. W. BUCKLEY, M.A., AND J. GUNSON, B.A. PAPER 2788E, JANUARY 1959 **Theory and behaviour of helix structures for a high-power pulsed travelling-wave tube** *April 1959*

H. J. CURNOW, B.SC., AND L. E. S. MATHIAS, M.SC. PAPER 2825E, JANUARY 1959 **A multi-cavity klystron with double-tuned output circuit** *April 1959*

F. H. JAMES. PAPER 2847E, FEBRUARY 1959 **A method for the measurement of very high Q-factors of electromagnetic resonators** *April 1959*

L. LEWIN. PAPER 2854E **Phase measurements through tapered junctions** *May 1959*

PART C. MONOGRAPHS (SEPTEMBER 1959)

See the Journal for September 1959, p. 557

District Meetings

ARRANGEMENTS for District Meetings in October and November other than in the area of a local Centre

October 1959

READING (at the George Hotel, King Street at 7.15 p.m.)

19 *Monday* C. A. BELCHER 'The provision of adequate installations in small houses and flats'

November 1959

OXFORD (at the Southern Electricity Board Service Centre, 37 George Street, at 7 p.m.)

11 *Wednesday* A. E. HAWKINS, B.SC.(ENG.) 'Modern coal-fired power station'

READING (at the George Hotel, King Street at 7.15 p.m.)

23 *Monday* R. C. M. BARNES, B.SC.(ENG.) 'An introduction to electronic computers'

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 18TH SEPTEMBER 1959

	No. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	894	9379	2	9
£2 to <£5	2180	6021	4	7
under £2	26 449	13875	16	6
		£45 142	6	10

SCHOLARSHIPS

THE following scholarships have been awarded by the Council for 1959:

RESEARCH SCHOLARSHIPS

Ferranti Scholarship (*tenable for two years*)

R. HAWLEY — to carry out research to determine the effects occurring at the surface of metallic electrodes in a high vacuum on the application of an electric field

Oliver Lodge Scholarship (*tenable for one year*)

R. C. FOSS — to undertake research on the second-harmonic magnetic modulator using ferrite materials

I.M.E.A. Scholarship (*tenable for one year*)

P. E. SECKER — to make a study of the fundamental processes of arc motion in a transverse magnetic field with particular reference to cathode-root phenomena

GRADUATE SCHOLARSHIPS

Silvanus Thompson Scholarship (*tenable for one year*)

P. N. T. WELLS — to pursue a one-year course in medical physics at the University of Bristol

STUDENT SCHOLARSHIPS

Duddell Scholarship (*tenable for three years*)

G. P. TURNER — to pursue the B.Sc.-degree course in electrical engineering at the Imperial College of Science and Technology, London University

G. EDMONDSON — to pursue the degree course in electrical engineering at Bristol University

Salomons Scholarship (*tenable for one year*)

D. R. FONES — to pursue the final honours-degree course in electrical engineering at Nottingham University

David Hughes Scholarship (*tenable for one year*)

K. A. HILL — to pursue the second-year honours-degree course in electrical engineering at the University of Manchester

Arthur Fleming Scholarship (*tenable for three years*)

M. J. PENNY — to pursue a professional-engineering sandwich course at the College of Technology, Rugby

OTHER AWARDS

Knight Fund

D. A. BELL — to undertake a senior trade scholarship at Belfast College of Technology

LENDING LIBRARY CATALOGUE

COPIES of the new edition of the Lending Library Catalogue which was referred to in the April 1959 *Journal*, p. 224, are now available. Unfortunately the printing dispute held up publication, but in order to ensure that the catalogue is as up to date as possible a short supplement listing all the books acquired during the period January–July 1959 has been included. The price is 3s. 6d. post-free.

GIFT OF LETTERS

THE Institution has received with gratitude a gift from Miss L. G. Morris, sister of the late Prof. J. T. MacGregor-Morris, of a number of letters of scientific interest between Prof. MacGregor-Morris and Sir Joseph Lister, N. Paul Jasper, Prof. Elihu Thomson, Oliver Heaviside and Prof. W. C. von Röntgen.

ARRANGEMENTS WITH ENGINEERING INSTITUTIONS OVERSEA

MEMBERS who may have to travel abroad are reminded that in certain countries reciprocal arrangements are in operation for the extension of privileges to visiting members. The complete list of institutions concerned is as follows:

Country	*Institution*
Australia	Institution of Engineers, Australia
Austria	Österreichischer Ingenieur- und Architekten-Verein
Belgium	Société Royale Belge des Ingénieurs et des Industriels
	Société Belge des Électriciens
Brazil	Instituto de Engenharia, São Paulo
Canada	Engineering Institute of Canada
Denmark	Dansk Ingeniørforening
Finland	Suomalaisten Teknikkojen Seura
	Tekniska Föreningen i Finland
France	Société des Ingénieurs Civils de France
	Société Française des Électriciens

Germany	Verein Deutscher Ingenieure
	Verband Deutscher Elektrotechniker
Holland	Koninklijk Instituut van Ingenieurs
Iceland	Association of Chartered Engineers in Iceland
India	Institution of Engineers, India
Italy	Associazione Elettrotecnica Italiana
Japan	Institute of Electrical Engineers of Japan
New Zealand	New Zealand Institution of Engineers
Norway	Norsk Elektroteknisk Forenung
	Den Norske Ingeniørforenung
Rhodesia	Rhodesian Institution of Engineers
South Africa	South African Institution of Civil Engineers
	South African Institute of Electrical Engineers
	South African Institution of Mechanical Engineers
Sweden	Svenska Teknologföreningen
Switzerland	Schweizerischer Ingenieur- und Architekten-Verein
Turkey	Turkish Engineering Society
United States	American Institute of Electrical Engineers
	American Institute of Chemical Engineers
	American Institute of Mining and Metallurgical Engineers
	American Society of Civil Engineers
	American Society of Mechanical Engineers
	Institute of Radio Engineers

The Secretary will gladly provide letters of introduction for members visiting these countries.

REVIEW OF THE PROCEEDINGS OF THE SECOND GENEVA CONFERENCE

THE *Journal of the British Nuclear Energy Conference* is to publish a list of the content of each volume of the proceedings of the second United Nations international conference on the peaceful uses of atomic energy (Geneva, the 1st–13th September 1958) as it becomes known. The Library of the Institution of Civil Engineers will have a complete set of the proceedings which will be held for the use of members of the constituent societies of the British Nuclear Energy Conference. The following volumes have been ordered for the Library of our Institution, and those marked with an asterisk have been received:

Vol. 33—Index of the proceedings; Vol. 7.—Reactor technology; Vol. 8*—Nuclear power plants—1; Vol. 9—Nuclear power plants—2; Vol. 10*—Research reactors; Vol. 11*—Reactor safety and control; Vol. 12*—Reactor physics; Vol. 13—Reactor physics and economics; Vol. 14*—Nuclear physics and instrumentation; Vol. 15*—Physics in nuclear energy; Vol. 16—Nuclear data and reactor theory; Vol. 17*—Processing irradiated fuels and radioactive materials; Vol. 22—Biological effects of radiation; Vol. 23*—Experience in radiological protection; Vol. 31*—Theoretical and experimental aspects of controlled fusion; and Vol. 32*—Controlled-fusion devices.

COURSES IN HIGHER TECHNOLOGY

THE London and Home Counties Regional Advisory Council for Technological Education have issued their bulletin of special courses in higher technology including management studies and commerce for the autumn term 1959–60. The courses do not regularly appear in college calendars or prospectuses as part of a grouped course or as subjects offered for endorsement on Higher National Certificates.

They are as a rule part-time (usually evening) courses, but full-time courses which are specially arranged and are not of longer than three months' duration are included. The bulletin may be obtained from the Secretary, Regional Advisory Council, Tavistock House South, Tavistock Square, London W.C.1., price 3s. 6d. post-free.

British Nuclear Energy Conference

DETAILS of four forthcoming meetings of the British Nuclear Energy Conference are given below. Papers and discussions on the applications of nuclear energy and ancillary subjects are published in the quarterly *Journal of the British Nuclear Energy Conference*. The annual subscription payable by members of The Institution who wish to receive the *Journal of the B.N.E.C.* regularly is 30s. post-free. Single copies are available at 7s. 6d. each

1959

NOVEMBER 4 *Wednesday* (6 p.m.)

Sponsoring society and place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

DESIGN AND TESTING OF LARGE GAS DUCTS A. T. Bowden and J. C. Drumm

NOVEMBER 18 *Wednesday* (6 p.m.)

Sponsoring society and place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

Informal discussion on TO WHAT EXTENT SHOULD DESIGN WAIT ON RESEARCH FOR NUCLEAR POWER PLANT?

NOVEMBER 24 *Tuesday* (2.30 p.m.)

Sponsoring society: The Institution of Chemical Engineers

Place of meeting: The Royal Institution, Albemarle Street, London W.1

SYMPOSIUM ON NUCLEAR ENERGY

SECOND URANIUM PRODUCTION PLANT AT SPRINGFIELDS R. C. Alexander, L. P. Shortis and C. J. Turner

PROCESSING OF URANIUM ORES AND CONCENTRATES TO PURIFIED URANYL NITRATE SOLUTION H. Page, L. P. Shortis and J. A. Dukes

FLUIDIZED-SOLIDS DRYWAY PROCESS FOR THE PRODUCTION OF URANIUM TETRAFLUORIDE E. Hawthorn, L. P. Shortis and J. E. Lloyd

PUMPING STUDIES ON AQUEOUS THORIA SLURRIES R. Murdoch and H. A. Kearsey

USE OF HYDROGEN AS A REACTOR COOLANT D. Bradlay

NOVEMBER 25 *Wednesday* (6 p.m.)

Sponsoring society and place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

Thomas Hawksley lecture on EFFECT OF NUCLEAR RADIATION ON ENGINEERING MATERIALS A. H. Cottrell

Tickets may be obtained from the Secretary of The Institution of Mechanical Engineers

OVERSEA ATTENDANCE REGISTER

DURING the period 17th August to 15th September 1959 these members called at the Institution building and signed the Attendance Register of Oversea Members:

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BULLETIN OF THE SECTIONS

UTILIZATION

Some remarks from the Chairman

In a recent series of articles in the *Journal* on their history, structure and scope the four specialized Sections of The Institution were called for the first time 'The four pillars of The Institution'. This description is one of great significance for it clearly implies that The Institution is relying to a large extent on the activities of the specialized Sections in the pursuit of its aim of 'grouping specialists towards certain limited and particular objectives, within a united profession capable of sustaining far larger aims'.

The strength of The Institution may therefore be said to be that of its weakest pillar, and it is incumbent on the members of the Utilization Section to see that we are not blameworthy in this respect.

The opening of a new session provides a suitable opportunity of considering this aspect of our function, reviewing the past as well as looking to the future, in order to see if we are in any way lacking in facing up to our responsibilities.

Membership

First of all let us look at the Section membership. The utilization of electricity is in one way or another the concern of almost every electrical engineer, and one would expect that a very large fraction of the Institution membership would belong to the Utilization Section. This is however not so, and at the end of August 1959 out of a total Institution membership of 45000 only 5000 were registered members of the Section.

Since the strength of the Section depends on a full and active membership I would ask all those members of The Institution whose work is concerned with the utilization of electricity and who have not yet joined the Section to reflect on their position, to register with the Section and to take an active interest in its work.

Retrospect

Looking back I think it may be fairly claimed that we played a full part in the life of The Institution during the session just ended. There was a full programme of seven ordinary meetings, the customary annual lecture which was of the usual high standard and well attended, and a very successful half-day meeting at which was presented a symposium of papers on the important subject of 'Provision of adequate electrical installations in buildings'.

Special mention should also be made of the joint meeting with the London Graduate and Student Section at which three excellent papers were read by junior members and which is arranged annually to give practical effect to our desire to encourage younger members to prepare papers for reading and discussion and thereby promote their interest in the work of The Institution.

The attendances at these meetings were on the whole reasonably good especially when the papers were concerned with the more practical side of our interest.

It is good to know too that the four Utilization Groups in the Provinces continued to receive enthusiastic support from their members and that they all had full programmes of meetings and visits.

The new session

As to the new session although there has been some difficulty in securing suitable papers we shall doubtless have a full programme which will cover some new aspects of the use of electricity. Members concerned with rectification will be interested in the papers on 'The characteristics and protection of semiconductor rectifiers' by D. B. Corbyn and N. L. Potter, while a paper of practical interest to many will be 'Submersible pumping plant' by H. H. Anderson and W. G. Crawford.

Then early in the New Year the Supply and Utilization Sections have been invited by the Measurement and Control Section to participate in a joint meeting; the two papers to be read and discussed are 'A new method of observing the phenomena of commutation' by H. J. H. Sketch, P. A. Shaw and R. J. K. Splatt and 'A method of measuring self-inductances applicable to large electrical machines' by J. C. Prescott and A. K. El-Kharashi. Joint meetings such as this admirably illustrate the mutual dependence of the four Sections in the structure of The Institution, and as there is much in the two papers to be presented on this occasion which will be of considerable interest to members of the Utilization Section it is hoped there will be a good attendance of the latter.

Practical papers

There appears to be a feeling abroad that papers of a highly technical or mathematical nature are more acceptable to the Section than those dealing with the practical aspect of our work. This is emphatically not the case: although papers concerned with the theoretical side are desirable and indeed essential if progress is to be made, others dealing with the up-to-date practical application of the use of electricity in all branches of industry are equally acceptable, and our recent programmes have shown, I feel, that the Section is maintaining a reasonable balance between the two types of paper.

I would therefore appeal to all members who have some useful knowledge to impart not to hold back in submitting a paper because they think it may not be sufficiently technical or mathematical in its approach.

An adequate flow of first-class papers of both types together with good and enthusiastic attendances at our meetings are essential to ensure that the Section continues to be a worthy unit of the quadripartite support of The Institution.

T. E. HOUGHTON

SUPPLY

Financial need and meed

EMINENT specialist engineers usually from oversea have given entertaining accounts of the progress of electrification in their countries. Mr. P. J. Squire of Washington is a fellow-countryman and a member of The Institution, and in welcoming him at Savoy Place on the 20th May 1959 the Chairman, Mr. D. P. Sayers, mentioned the double pleasure given to members in having for their annual lecture both the author and his subject of the operation of the World Bank.

Stability and construction

Founded 15 years ago to act in several roles the bank provides funds to overcome short-term difficulties and thereby encourage stability and makes loans under guarantee which were initially particularly directed towards reconstruction and are now concerned with construction. One-third of the funds available have been employed to create 9000 MW of generating capacity. The bank is financed by member countries and from private sources.

Mr. Squire explained how suggested projects are appraised in relation to national economic strength and technical soundness and the part played by him and his colleagues in providing consulting services.

He instanced a number of cases where the bank had advanced loans and how the managerial aspects receive careful study. It is axiomatic that projects must not only be feasible financially and technically but also be coupled with a sound administrative structure.

A scheme in the Philippines

Dealing in detail with a particular hydroelectric scheme in the Philippines he explained the development of the scheme from its inception, the construction, the commissioning and the continued association of the World Bank during operation.

Dr. J. R. Mortlock in a series of revelations associated with the author's past showed how his natural propensities had led him into his chosen vocational field. He expressed the thanks of the members present.

Prof. M. G. Say seconded the proposal in a welter of stock-exchange terms coupled with an indication that banks apparently are not always places where overdrafts are kept.

The Chairman then presented Mr. Squire with a token to mark the occasion and record the appreciation of the Section.

F. C. W.

Broadmanship

'I SEEM to have lost interest in Institution meetings; the papers are too specialized, and we don't get those broad subjects in which everyone can take an interest.' Such were the recent words of a younger colleague of mine referring particularly to the Supply Section. When I pointed out that one of our papers during the current session was 'bang on' his own line of country and another very close to it he admitted with regret that he had not attended those particular meetings. So in this case I would say we had a complete alibi, but the remark symbolizes a problem which is always with us.

At a time when knowledge is expanding in all directions with its inevitable demand for more and more specialization how is it possible in the course of less than a dozen meetings during the session to cover the ground so as to interest the maximum number of members; to use planning parlance how can we 'optimize' the programme?

Assessing merits

In the case of the Supply Section I think the answer is fairly easy. The merits of a paper should be assessed broadly in two ways. First the basic subject should be one which concerns in one way or another a substantial number of members; secondly the particular aspect dealt with must of course fulfil The Institution's requirements as regards quality, originality and so on. However if the first condition is met, so far as the meeting is concerned the paper becomes a broad field over which the discussion should range far and wide.

In the present session the Supply Section have had papers covering cables, transformers, switchgear, arc discharges, turbo-alternators, station works supplies and nuclear-reactor auxiliaries together with the annual lecture on the operations of the World Bank. It might be overstating the case to claim that such a list covers the interest of all members of the Section, but surely any gaps left are not very wide. In no case was the discussion confined merely to the special aspect dealt with in the paper, and to my mind this is as it should be.

For example the paper on cables was written solely on the gas-filled cable system, but the discussion in which more than 20 speakers took part ranged over the whole field of high-voltage cables.

A tangential view

If the title of a paper is 'Design of X' it is a complete fallacy to assume that it is only for the intellectual refreshment of the designer—the designer, the constructor, the operator and the maintenance man are all closely interdependent, and the views of any one of them are vital to the others. The contributor to the discussion who comes in or goes off at a tangent is frequently the 'hit' of the meeting, particularly if he makes his points in an unorthodox manner.

The clamour for authors with subjects of broad general interest is understandable but to some extent unrealistic in the present state of our profession. It is the members themselves who submit papers, and it is up to other members to bestow that degree of broad general interest on a particular subject by the breadth and quality of their contribution to the discussion.

By and large and judged by the attendance and the numbers taking part in the discussions I think the Supply Section has provided its members with adequate fare during the past session. The formal meetings as well as the less formal gatherings have well maintained the traditional friendliness and camaraderie of the Section which play no small part in a better understanding of the other man's point of view.

Thirst for knowledge

The social events have been well supported, and there was a record attendance of almost 400 at the annual dinner-dance. The summer outing to Aldermaston and to the river at Marlow was also a successful occasion thanks to ideal weather, the hospitality of our friends and the happy atmosphere.

The annual visit, to Dublin, was equally successful. It appears that one of the most popular technical calls on that occasion was to Guinness's brewery. Surely this demonstrates that the Supply Section loses no opportunity of catering for every taste and for quenching as well as stimulating the thirst for knowledge.

D. P. SAYERS

MEASUREMENT AND CONTROL

Summer visit

On Saturday morning the 27th June 1959, 77 members and their ladies visited one of the factories of Standard Telephones and Cables and their associates Kolster-Brandes at Footscray, Kent.

The party headed by Mr. J. K. Webb were received by Mr. P. H. Spagnoletti, manager of the companies' components group, and were first entertained to coffee in the executive dining-room, an excellent vantage-point from which they enjoyed a view of the delectable grounds.

In a conducted tour of the factories under the expert guidance of the companies' officials members had the opportunity of inspecting in detail some of the manufacturing operations and testing procedures behind a wide range of products. The high standard of the interesting exhibits and demonstrations impressed everyone.

Mr. P. H. Spagnoletti greets Mr. J. K. Webb on his arrival at Footscray

After the tour cocktails preceded lunch at which Mr. Spagnoletti presided. He welcomed the party to Footscray.

Elegance in the pre-electrical era

Mr. Webb replied on behalf of the Section. He thanked Mr. Spagnoletti and all concerned for the hospitality and for the skill and care with which the exhibits had been arranged. The President, Mr. S. E. Goodall, was unfortunately unable to be present, but a recording of a message from him in which he sent his greetings to the assembly was broadcast and much appreciated by those present.

After speeches from Prof. A. Tustin, Section Chairman-Elect, who gave an absorbing and humorous account of his recent visit to Russia, and Mr. P. P. Eckersley whose contribution was in characteristic vein, the party left Footscray for Knole Park, Sevenoaks, where they had the opportunity of visiting Knole House, the ancient home of the Sackvilles. Here they could contrast life at its most elegant in a pre-electrical era with the 'mod. cons.' which we now enjoy and reach their own conclusions.

Tea was afterwards served at Bligh's Hotel, Sevenoaks, where the general atmosphere of cheerfulness and the animation of the conversation tended to show that the day had been most successful.

J. K. W.

ELECTRONICS AND COMMUNICATIONS

High-quality microphones

At Savoy Place on the 23rd March 1959 Mr. M. L. Gayford presented his paper on 'High-quality microphones' in which he reviews present-day practice in the design and operation of high-grade units such as are used in broadcasting, sound recording, acoustical measurement, etc. An article based on the paper (2798) appears on p. 589. Mr. M. J. L. Pulling was in the chair.

Mr. H. A. M. Clark opened the discussion by referring to the more stringent requirements, as regards precision of control characteristics and matching, of microphones used for stereophonic purposes. He commented on the growing interest in sound pick-ups which use the polar diagrams of microphones as the origin of the stereophonic effect.

Mr. D. W. Robinson mentioned the limitations imposed on instrument microphones by thermal noise in the effective series-resistance component of the electrical impedance or by amplifier noise.

Mr. D. E. L. Shorter could not remember a previous survey paper on the subject and congratulated the author on his timely contribution. He bemoaned the parochialism of British and American textbooks in failing to recognize developments until they had been in regular use for some 20 years.

Like Mr. Robinson Mr. R. B. Archbold is interested in instrument microphones, and he asked for more information on the respective stability of moving-coil and condenser microphones.

Referring to wind-shielding Mr. H. D. Harwood said that too efficient shielding might produce unnatural effects owing to the change in speech quality caused by speaking in a high wind.

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